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PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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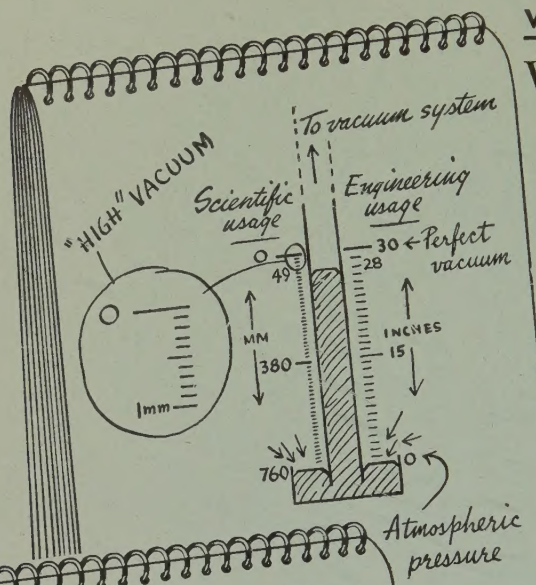
VOLUME 56 APRIL 1953 NUMBER 664

PAGES FROM OUR VACUUM NOTE BOOK

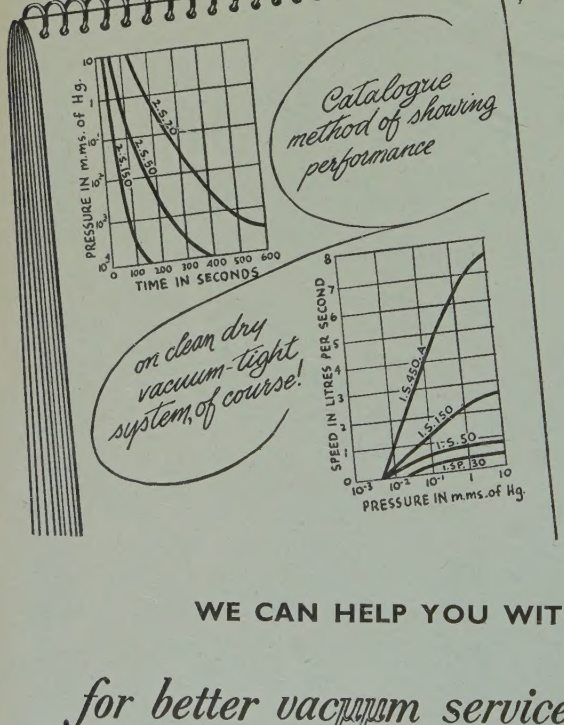


VACUUM NOTES: No. 1.

What do YOU mean by "VACUUM"?

If we hark back to fundamentals . . . Pressures b atmospheric pressure are measured with referen a column of mercury. The standard atmosphe able to support, and is therefore equivalent to pressure exerted by a column 760 mm or 29·9 in The Engineer measures the difference betwee pressure inside and the pressure outside the sy whilst the scientist measures the *absolute pressu* his vacuum system.

Pressures below 1 millimetre of mercury (mm Hg the most important to the physicist, and us termed "High" vacuum. The unit of measureme the micron, 1 micron (1 μ) being equivale 0·001 mm Hg.



VACUUM NOTES: No. 2.

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If you were to consult us as to which of the range of "Speedivac" Rotary Pumps would best your particular requirements, we should ask you basic questions:

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(3) What amount of gas will be liberated during the pr
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Principal Contents

APRIL 1953

		PAGE
51	MATHEMATICS	285
52	ASTRONOMY. ASTROPHYSICS. GEODESY	285
53	PHYSICS	288
530.1	Fundamentals	288
531	General mechanics. Mechanics of solids	295
531.7	Mechanical measurements	296
532	Mechanics of fluids	296
532.6	Capillarity	—
532.7	Molecular theory of liquids	298
533	Mechanics of gases	300
533.7	Molecular theory of gases	300
534	Vibrations. Acoustics	301
535	Optics. Radiation. Spectra	308
536	Heat	320
536.7/.8	Thermodynamics	323
537	Electricity	324
537.1	Theory. Electrons	324
537.2	Electrostatics. Dielectrics	324
537.3	Electric conduction. Currents	325
537.52	Electric discharges	329
537.531	X-rays	330
537.533/.534	Cathode rays. Positive rays	330
537.54	Discharge tubes. Counters	333
537.56/.58	Ionization. Thermionics	334
537.591	Cosmic rays	335
538	Magnetism	337
538.3/.5	Electromagnetism. Electrodynamics	339
538.56	Electromagnetic waves and oscillators	340
538.6	Magnetic effects	343
539.1	Molecular and atomic structure	343
539.11	Theory of solid state	343
539.13	Molecular structure	344
539.15	Atomic structure. Nucleus. Isotopes	346
539.16	Radioactivity. α-, β- and γ-rays	350
539.17	Nuclear reactions	356
539.18	Atom and molecular beams. Mesons. Neutrons	362
539.2	Structure of solids	364
539.3/.8	Elasticity. Strength. Rheology	366
541	PHYSICAL CHEMISTRY	368
541.11/.12	Phase equilibrium. Chemical reactions	368
541.13	Electrochemistry	369
541.14/.15	Photochemistry. Radiation chemistry	370
541.18	Dispersions. Colloids. Adsorption	370
541.2/.6	Chemical structure	371
542.1/.7	Laboratory apparatus	—
542.9	Chemical processes	372
543/545	Chemical analysis	372
548	CRYSTALLOGRAPHY	372
548.7	Molecular and X-ray crystallography	373
55	GEOPHYSICS	377
551.5	Atmosphere. Meteorology	377
57/59	BIOLOGY	380
61	Medical science. Human physiology	381
66/67	TECHNICAL MATERIALS	—
77	PHOTOGRAPHY	382

RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Amplifiers
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953). Reprints of the List of Journals can be obtained from the Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Arch. Eisenhüttenw.	*Archiv. für Eisenhüttenwesen.* [Reprinted in *Entwicklungsber. Siemens & Halske.*]
Bull. Chem. Soc. Japan	*Bulletin of the Chemical Society of Japan.* [Abstracted by *British Abstracts.*]
Bull. Nagoya Inst. Technol.	*Bulletin of the Nagoya Institute of Technology.* Nagoya, Japan.
Electrotech. Pap. [*Tokyo*]	*Electrotechnical Papers.* Institute of Electrical Engineers of Japan, No. 1, 1-chome, Yuraku-cho, Chiyoda-ku, Tokyo.
J. Amer. Rocket Soc.	*Journal of the American Rocket Society.* 29 West 39th Street, New York 18.
JENER Publ.	*JENER Publications.* Joint Establishment for Nuclear Energy Research, Kjeller per Lillestrøm, Norway.
JENER Rep.	*JENER Report.* Joint Establishment for Nuclear Energy Research, Kjeller per Lillestrøm, Norway.
Kolloid Z.	*Kolloid Zeitschrift.* [Abstracted by *British Abstracts.*]
Lichttechnik	*Lichttechnik.* Helios-Verlag, Eichborndamm 141–167, Berlin-Borsigwalde.
Marconi	*Marconi.* Via Hermada 2, Genova-Sestri.
Sci. Rep. Saitama Univ.	*Science Reports of the Saitama University. Series A (Mathematics, Physics and Chemistry).* Saitama University, Urawa, Japan.
Tímarit Verkfræd. Islands	*Tímarit Verkfrædingafélags Islands.* P.O. Box 645, Reykjavik, Iceland.
Z. Elektrochem.	*Zeitschrift für Elektrochemie.* Berichte der Bunsengesellschaft für physikalische Chemie. Verlag Chemie G.m.b.H., Weinheim/Bergstrasse.

Notes

Austral. J. Phys.	*Australian Journal of Physics*—formerly *Australian Journal of Scientific Research, Series A: Physical Sciences*, which has been divided into *Australian Journal of Physics* and *Australian Journal of Chemistry* (each issued quarterly) as from first issue of 1953.
J. Photogr. Sci.	*Journal of Photographic Science*—formerly *Photographic Journal, Section B.* Title changed as from issue of January, 1953.

Errata

Abstr. 3600 (1952), line 3: *for* KOSINA, T. I. *read* KOSTINA, T. I.

Author Index (1952), p. 1224, line 15, entry under MAYNEORD, W. V., TURNER, R. C., NEWBERY, S. P., and HODT, H. J.: *for* 1382 *read* 1372.

Subject Index (1952), p. 1336, column 1, line 13 from bottom: *the entry* metallic, thermal expansion 8115 *should be listed under* **Gadolinium**, *not* **Gallium.**

p. 1405, column 1, last line: *for* Ga *read* Gd.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

Abstr. 9042 (1952): **7,** 603 (*May–June*, 1952).

Abstr. 362 (1953): **21,** 381 (*Feb.*, 1953).

Abstr. 1244 (1953): **41,** 218 (*Feb.*, 1953).

MATHEMATICS 51

518.5

2137. An electronic differential analyzer. K. R. SYMON AND R. P. POPLAWSKY. *Amer. J. Phys.*, **21**, 53–63 (*Jan.*, 1953).

An electronic differential analyser designed primarily for classroom teaching is described. The value of building such a device as a project for advanced students is emphasized. The method of setting up differential equations on the differential analyser is explained, and a few sample solutions are illustrated. A.

518.5 : 621.317.79 : 621.3.012.8

2138. The use of extrapolation techniques with electrical network analogue solutions. R. CULVER. *Brit. J. appl. Phys.*, **3**, 376–8 (*Dec.*, 1952).

Outlines briefly simple numerical techniques which are used in finite-difference mathematics to estimate the infinitesimal result from finite difference solutions taken with various network sizes. By virtue of the direct analogy between first-order difference operators and electrical network voltages, these techniques are directly applicable to extrapolation procedures on characteristic values obtained from networks. The importance of selecting an extrapolation form consistent with the accuracy of the individual characteristic value determinations is emphasized. A.

518.5 : 621.318.572

2139. The preparation of programs for an electronic computer. M. V. WILKES, D. J. WHEELER AND S. GILL. *Cambridge, Mass., Addison-Wesley* (1951), 167 *pp*.

Review in *Rev. sci. Instrum.*, **24**, 63–4 (*Jan.*, 1953). "Although these methods are described in terms of the code of orders used in the Electronic Delay Storage Automatic Calculator (EDSAC) at the University of Cambridge, England, they are clearly applicable to many other large-scale calculators."

518.5 : 621.318.572

2140. Decision elements. III. J. D. GOODELL. *Radio-Electronic Engng*, **1952**, 14–16, 31 (*Sept.*).

The general considerations of the previous papers [Abstr. 8629–30 (1952)] are extended to the cases of serial and parallel operation and to the problems of clock synchronization. A. J. KENNEDY (R)

518.5 : 621.318.572

2141. Decision elements. IV. J. D. GOODELL. *Radio-Electronic Engng*, **1952**, 10–12 (*Oct.*).

An approach to the problem of computer programming is outlined. Initially, the programme is set up as conveniently as possible, then reformed using negating considerations, and finally the elements reconnected to the direct or negated output of the preceding element in such a way that negations are eliminated. Facility in this process is quickly gained with practice: an example is discussed. The "general purpose" class of machine is distinguished from the differential analyser and the application of decision elements to the two cases compared.

A. J. KENNEDY (R)

518.5 : 621.318.572

2142. DINA, a digital analyser for Laplace, Poisson, diffusion, and wave equations. C. LEONDES AND M. RUBINOFF. *Commun. and Electronics, No.* 3, 303–9 (*Nov.*, 1952).

The logical basis and the general form of an unconstructed electronic machine are described. This is to solve the Laplace equation, $\nabla^2 u = 0$, in its Cartesian form (even when u is meromorphic), or one of its three common related equations. Difference equations are set up and solved by an iterative process, Liebmann's and Richardson's methods being discussed in relation to the machine problems. Its characteristics are summarized and compared with the large general-purpose machines. No design details are given. There are 27 references to analogue and digital devices concerned with this class of equation, and 23 references to the mathematical techniques.

A. J. KENNEDY (R)

519.2 : 621.391

2143. A note on information theory. S. KULLBACK. Letter in *J. appl. Phys.*, **24**, 106–7 (*Jan.*, 1953).

A brief account of an approach to information theory through statistical discrimination theory. A "distance" between two distributions (e.g. transmitted and received signal) is defined and its relationship to signal-noise ratio investigated. N. L. JOHNSON

519.41

2144. Two applications of group characters to the solution of boundary-value problems. E. STIEFEL. *J. Res. Nat. Bur. Stand.*, **48**, 424–7 (*June*, 1952).

It is shown that the numerical work involved in solving a boundary-value or eigen-value problem by finite difference methods in a domain with many symmetries can often be reduced by applying the theory of group characters to the group of symmetries of the domain. In the second part the author considers the problem of solving $\Delta u = 0$ in a cube when the prescribed boundary values are invariant under the group of rotations of the cube. In the series representation of the solution in terms of harmonic polynomials only a subset of these polynomials actually occurs, and the theory of group characters facilitates considerably the determination of this subset. A.

ASTRONOMY . ASTROPHYSICS . GEODESY 52

522.612

2145. The spectrographic equipment of the 200-inch Hale telescope. I. S. BOWEN. *Astrophys. J.*, **116**, 1–7 (*July*, 1952).

The relationships between spectrograph speed and the various parameters entering into spectrograph design are discussed, and a description is given of the optical designs that have been worked out for the spectrographs of the Hale telescope to take advantage of these relationships. Three new optical features

were introduced in the design of the coudé spectrograph: (1) As dispersing element, a composite of four matched gratings is used; (2) cameras are of the Schmidt type, with the corrector plate placed practically in contact with the grating, the light passing through the plate twice, once before and once after reflection at the grating (this eliminates many of the vignetting problems present when the corrector plate is placed in the conventional position); (3) for the shortest focal-length camera an aplanatic sphere is combined with a Schmidt camera, thereby permitting a considerably higher camera speed than that attainable with the Schmidt camera alone. With the aid of these new features, a spectrograph has been constructed having a 12-in. aperture collimator beam and a series of five cameras with focal lengths ranging from 144 to 8·4 in. and yielding dispersions of 2·3 to 40 A/mm. For the study of the faintest objects a small spectrograph has been built for use at the prime focus. This has a 3-in. aperture collimator and cameras of focal length 1·4 and 2·8 in. A.

523.112 : 523.852

2146. Clusters of nebulae in an expanding universe. G. LEMAÎTRE. *Monthly Notes Astron. Soc. S. Africa*, **11**, 110–17 (*Nov.*, 1952); also in *S. African J. Sci.*, **49**, 80–6 (*Oct.–Nov.*, 1952).

A general report in non-mathematical terms of the author's models for nebular clusters [Abstr. 8468 (1951)] with particular reference to the cosmological implications of the observed large dispersion from the mean of the radial velocities of nebulae in a cluster.

R. A. NEWING

523.161 : 551.593.5 : 535.42

The Mie theory of diffraction through dielectric spheres with absorbing cores and its application to problems of interstellar matter. *See Abstr.* 2387

523.165

2147. The measurement of the angular diameter of radio stars. F. G. SMITH. *Proc. Phys. Soc.* [*London*] *B*, **65**, 971–80 (*Dec.*, 1952).

A new method of using interferometers to measure the diameters of radio stars is described. The method is based on the use of the phase-switching system, and has several practical advantages over previous methods. Measurements which have been made on the radio star (23·01) in Cassiopeia, indicate that the radio star has an angular diameter of about 5′ arc, the exact value depending on the distribution of brightness across the star. A gaseous nebula reported by Baade, in the same position as the radio star, has about the same diameter. Some measurements have also been made on the radio star (19·01) in Cygnus, and this star appears to have an angular diameter of about $3\frac{1}{2}'$ arc. A.

523.5

2148. The physical theory of meteors. III. Conditions at the meteor surface. R. N. THOMAS. *Astrophys. J.*, **116**, 203–10 (*July*, 1952).

For Pt II, see Abstr. 3212 (1952). The conditions at the meteor surface are investigated. It is concluded that the conventional linearized heat-transfer equation cannot be applied to determine the surface temperature of meteors. On the basis of the reaction-rate approach, it is concluded either that the meteor surface vaporizes in all cases or that, if melting occurs, the droplets are so small as to require energies equal to some 50% of the vaporization energy to separate them from the meteor surface. A.

523.746

2149. Physical conditions in large sunspots deduced from their spectrum. R. MICHARD. *C.R. Acad. Sci.* [*Paris*] **235**, 1608–10 (*Dec.* 22, 1952) *In French.*

Spectra of sunspots (area ~ 80 millionths of solar hemisphere, and magnetic field ~3000 gauss) have been used to derive values of temperature, electronic and gas pressures at the centre of the spot-umbra as functions of optical depth ($\lambda = 5000$ Å). D. R. BARBER

523.75

2150. Model solar atmospheres. L. H. ALLER AND A. K. PIERCE. *Astrophys. J.*, **116**, 176–84 (*July*, 1952).

An iteration method is described for obtaining model stellar atmospheres when the temperature as a function of optical depth is known. This process is applied to the solar atmosphere, using an empirical temperature distribution based on observations of limb darkening. The total pressure, the electron pressure, and the absorption coefficient are tabulated as functions of the optical depth for different hydrogen-to-metal ratios. In addition, two solar models with He/H ratios of $\frac{1}{5}$ and $\frac{1}{20}$ are tabulated and compared with other models. A.

523.75

2151. A photometric survey of solar flares, plages, and prominences in Hα light. M. A. ELLISON. *Publ. Roy. Obs. Edinburgh*, **1**, *No.* 5, 75–112 (1952).

A detailed description of the photometric programme carried out at Edinburgh during the past 5 years with a combined spectrohelioscope and spectrograph. Objects have been: (i) to provide fully corrected line-profiles (in Hα light) for solar flares, plages (bright flocculi), and prominences of various types; (ii) to establish a scale of brightness for those classified solar features normally met with in routine observation. Various instruments used for the work are described, with particular attention to methods of eliminating, or reducing the different systematic errors involved in the photometry. A useful reproduction of representative daily sketches of solar features is included. D. R. BARBER

523.75 : 535.247.4

Isophotal contour densitometry: Application to solar flares. *See Abstr.* 2309

523.841.37

2152. The zero-points of the period-luminosity relations for Cepheids, and for R R Lyræ. H. MINEUR. *C.R. Acad. Sci.* [*Paris*] **235**, 1607–8 (*Dec.* 22, 1952) *In French.*

Priority is claimed for the recent (1952) discovery of Baade that the zero-point of the period-luminosity curve for the Cepheid population of M 31 is higher than that for the RR Lyrae stars, the Cepheids being distinctly brighter. The author found (1944) a difference of 1·22 m. in the same sense as Baade's.

D. R. BARBER

523.841.9

2153. The determination of a light-time orbit. J. B. IRWIN. *Astrophys. J.*, **116**, 211–17 (*July*, 1952).

The apparent variation of period arising from the

variation of distance of an eclipsing binary from the observer as a result of the gravitational attraction of a distant third component is considered. Woltjer's analytical method is extended and modified. Tables are presented which form the basis of a new graphical method which is both accurate and short. A.

523.852

2154. The predominating orientation of filaments and other structural details in gaseous nebulae. G. A. Shaĭn and V. F. Gaze. *Dokl. Akad. Nauk SSSR*, **82**, *No.* 6, 857–60 (1952) *In Russian.*

523.855

2155. A theory of the spatial distribution of galaxies. J. Neyman and E. L. Scott. *Astrophys. J.*, **116**, 144–63 (*July*, 1952).

A theory of the spatial distribution of galaxies is built, based on the following four main assumptions: (i) galaxies occur only in clusters; (ii) the number of galaxies varies from cluster to cluster, subject to a probabilistic law; (iii) the distribution of galaxies within a cluster is also subject to a probabilistic law; and (iv) the distribution of cluster centres in space is subject to a probabilistic law described as quasi-uniform. The main result obtained is the joint probability generating function $G_{N_1, N_2}(t_1, t_2)$ of numbers N_1 and N_2 of galaxies visible on photographs from two arbitrarily placed regions ω_1 and ω_2, taken with fixed limiting magnitudes m_1 and m_2, respectively. The theory ignores the possibility of light-absorbing clouds. The function $G_{N_1, N_2}(t_1, t_2)$ is expressed in terms of four functions left unspecified, which govern the details of the structure contemplated. Methods are indicated whereby approximations to these functions can be obtained and whereby the general validity of the hypotheses can be tested. A.

523.855

2156. Radial velocities and masses of double galaxies. T. Page. *Astrophys. J.*, **116**, 63–80 (*July*, 1952).

With a grating spectrograph at the prime focus of the 82-in. reflector, spectra have been obtained of 20 double galaxies at approximately 330 Å/mm dispersion. For each exposure, the slit was placed across both members of a pair and guided accurately so that two spectra appear side by side between the comparison spectra on each film. These films were measured both for the mean radial velocity of each pair, V, values of which range from 900 to 6700 km/sec, and for the difference in radial velocity between the two members of each pair, ΔV, which ranges from 0 to 360 km/sec. Measurement was facilitated by the emission lines, Hα and [O II] λ3727, which appear in many of the spectra. The errors are estimated to be about ±100 km/sec in V and ±30 km/sec in ΔV. Using the measured values of V, the velocity-distance relation, and the angular separations, the projected linear separation of each pair is derived. From this and the measured value of ΔV, and assuming circular orbits, a "double-angled mass function" is obtained for each pair. The mean of these mass functions yields as a mean mass for the components of double nebulae, the value 8×10^{10} solar masses with an estimated observational error less than ±40%. Although the observations do not yet permit an accurate determination of the frequency distribution of masses among these nebulae, there is good evidence in these and other data that many individual masses are over twice the mean, and many others are one-tenth the mean or less. In fact, these limited data indicate a sharp division between heavy-weight and light-weight galaxies of $1{\cdot}5 \times 10^{11}$ and $0{\cdot}5 \times 10^{10}$ solar masses, respectively. A.

523.87

2157. The equation of transfer and the residual intensities in spectrum lines. G. R. Burbidge and E. M. Burbidge. *Astrophys. J.*, **116**, 195–202 (*July*, 1952).

The equation of transfer for a spectrum line has been obtained, following earlier work by Strömgren, for lines arising from the level $n = 2$. Certain cyclic processes have been taken into account. The solutions of the equation of transfer for a point in the line and a point in the neighbouring continuum are written down following the work of Chandrasekhar. Criteria for the appearance of emission at any point in the line are obtained and discussed. The results are compared with those obtained by Miss Underhill. The theory is applied numerically to calculate the condition for emission to appear at the centres of the Balmer lines Hα, Hβ and Hγ under a chosen range of stellar temperatures and electron pressures. The simplifying assumptions have been made that the line centre is produced in the surface layer of the atmosphere and that Stark effect is not important here. The results show that at high temperatures the condition for emission in terms of the departure of the atmosphere from thermodynamic equilibrium will not be difficult to fulfil. It is also found that the condition for emission is relatively insensitive to the values of the coefficients of line absorption, continuous absorption and electron scattering, corresponding to a wide range of stellar conditions. A.

523.877

2158. The variable magnetic field of α^2 Canum Venaticorum. H. W. Babcock and S. Burd. *Astrophys. J.*, **116**, 8–17 (*July*, 1952).

This well-known peculiar star is found to have a strong magnetic field, the polarity of which is reversed in step with the periodic changes in line intensity. The Zeeman effect has been investigated on twenty-one spectrograms made with the double polarizing analyser. Polar magnetic-field strength and radial velocity for various elements have been tabulated as a function of phase in the period of 5·5 days. The extremes of H_p are approximately −4000 gauss when the Eu II lines are at maximum intensity and +5000 gauss a half-period later, when Cr II is at maximum. A.

523.877

2159. The time of relaxation for stars in a fluctuating density field. D. E. Osterbrock. *Astrophys. J.*, **116**, 164–75 (*July*, 1952).

A statistical method similar to that used by Chandrasekhar and Münch in their most recent analysis of the brightness fluctuations in the Milky Way is used to find the time of relaxation for a star moving through a fluctuating density field. The time required for the star to change its direction of motion

significantly because of gravitational interaction with the matter is calculated. The fluctuating density field represents a simplified model of the interstellar medium, and the computed time of relaxation for this case shows that the low-velocity stars can have had their velocities appreciably altered by gravitational interaction with the interstellar medium during 3×10^9 years, a result in agreement with that obtained by Spitzer and Schwarzschild. A.

523.877

2160. Compression waves in an atmosphere in radiative equilibrium. P. DUMÉZIL-CURIEN. *C.R. Acad. Sci.* [*Paris*] **235,** 1364–70 (*Dec.* 1, 1952) *In French.*

By means of the equations of hydrostatic, and radiative equilibrium, it is shown that the passage of a compression wave from the turbulent to the radiative zone of a stellar atmosphere generates acoustic radiation pressures of amplitude $>$ that of the real gravitational field. D. R. BARBER

525.241 : 538.11

A negative experiment relating to magnetism and the earth's rotation. *See Abstr.* 2531

526.72

2161. On the second-order correction terms to values of gravity measured at sea. B. H. WORSLEY. *Proc. Cambridge Phil. Soc.*, **48,** *Pt IV,* 718–32 (1952).

The motion of a pendulum on a periodically accelerated support has been studied by means of an electronic computing machine. The results have been applied to the problem of calculating the second-order correction to measurements of gravity made at sea with the Vening Meinesz three-pendulum apparatus. It is found that the correction for a single horizontal acceleration under typical conditions is likely to be more than twice that found analytically by Browne. His correction for vertical acceleration is valid for a wide range of frequency of the disturbing motion. A.

529.786

2162. Atomic clocks and frequency stabilization. C. R. S. INCE. Letter in *J. appl. Phys.*, **23,** 1408–9 (*Dec.*, 1952).

Points out 3 minor and 2 more serious errors in the paper reported in Abstr. 50 (1952). The corrected value for ε/ν is $1{\cdot}5\times10^{-3}$, and for ammonia the fractional frequency error for absorption is $4\pi\sqrt{2}\times$ that for dispersion. S. WEINTROUB

PHYSICS 53

FUNDAMENTALS 530.1

530.12

2163. Space and time. Q. MAJORANA. *R.C. Accad. Naz. Lincei,* **12,** 481–6 (*May,* 1952) *In Italian.*

530.12

2164. On a generalization of Schwarzschild's problem in a unified theory. Y. THIRY. *C.R. Acad. Sci.* [*Paris*] **235,** 1480–2 (*Dec.* 10, 1952) *In French.*

Spherically symmetric fields defined by a stationary cylindrical metric in 5-space reduce to the Schwarzschild gravitational fields in the particular case of general relativity, but in the general case electromagnetic fields are also present. The general exterior solution provides a purely electromagnetic field. R. A. NEWING

530.12

2165. A criticism of a recent unified field theory. C. P. JOHNSON, JR. Letter in *Phys. Rev.*, **89,** 320 (*Jan.* 1, 1953).

If there are solutions of Einstein's field equations of the form $g(x^i)$, then $g(kx^i)$ also provides a solution for any constant k. The solution $g(x^i)$ is taken to define the accelerations of two charged and one uncharged mass at large separations, and it is argued that if the Newton–Coulomb laws are satisfied, they will not also be satisfied for the corresponding situation defined by $g(kx^i)$. R. A. NEWING

530.12

2166. A comment on a criticism of unified field theory. A. EINSTEIN. Letter in *Phys. Rev.*, **89,** 321 (*Jan.* 1, 1953).

The criticism (preceding abstract) is based on the assumption that "similar solutions" $g(kx^i)$ for arbitrarily differing values of k can coexist in the same world, whereas interaction terms might introduce inadmissible singularities. Such a situation actually occurs in the two-body problem of pure gravitation theory. R. A. NEWING

530.12

2167. Spin and angular momentum in general relativity. P. G. BERGMANN AND R. THOMSON. *Phys. Rev.*, **89,** 400–7 (*Jan.* 15, 1953).

In the general theory of relativity, the group of co-ordinate transformations gives rise to four point-to-point conservation laws, which are usually identified with energy and linear momentum. In the presence of a semi-classical Dirac field, it is convenient to introduce at each point of space-time an arbitrary set of four orthonormal vectors (quadrupeds, "beine") and to consider the group of "bein" transformations, which then play the role of local, non-holonomic Lorentz transformations. A search for the corresponding conservation laws leads to terms that have the form of a spin angular momentum and which, in order to be conserved, must be supplemented by terms representing the orbital angular momentum. The technique of the so-called superpotentials has enabled us to introduce, in addition to the canonical stress-energy, a "contravariant" stress-energy which contains the usual symmetric Dirac and Maxwell terms and also asymmetric, purely gravitational terms. It is this set of expressions which enters into the orbital angular momentum. The techniques presented here are applicable to more general covariant theories, provided the gravitational field is represented by a metric tensor. A.

530.12

2168. Arbitrary concentrations of matter and the Schwarzschild singularity. A. RAYCHAUDHURI. *Phys. Rev.*, **89,** 417–27 (*Jan.* 15, 1953).

A non-static solution of the Einstein gravitational equations representing a spherically symmetric cluster of radially moving particles in an otherwise empty space is obtained. While it has been presumed by Einstein that the Schwarzschild singularity is physically

unattainable as matter cannot be concentrated arbitrarily, the present solution seems to show that there is no theoretical limit to the degree of concentration, and that the Schwarzschild singularity has no physical reality as it occurs only in some particular co-ordinate systems. Incidentally, it is shown that in case of spherical symmetry, the condition of conservation of gravitational energy of an isolated system of fluid material is equivalent to the vanishing of pressure at the boundary. A.

530.12 : 53.081

2169. The relativity of size. B. HOFFMANN. *Phys. Rev.*, **89**, 49–52 (*Jan.* 1, 1953).

A uniform change of size of all space-time intervals could not be detected, since the measuring instruments would be changed too. Therefore, a principle of similarity is proposed requiring that the equations of physics be invariant under such changes. This is shown to correspond to the principle that all units of interval are equivalent for expressing physical laws. It is pointed out that a given metrical tensor in the usual tensor calculus defines a specific unit of interval, so that the principle of similarity requires an enlargement of the tensor formalism and a corresponding change in the underlying geometry. A.

530.12 : 530.145

2170. The similarity theory of relativity and the Dirac–Schrödinger theory of electrons. B. HOFFMANN. *Phys. Rev.*, **89**, 52–9 (*Jan.* 1, 1953).

The similarity theory of relativity is shown to contain the recent Dirac–Schrödinger theory of electrons as a special case. The variational principle is built on the curvature scalar formed from the basic symmetric similarity tensor $S_{\sigma\tau}$, and leads to a unified field theory of the gravitational field, the electromagnetic field, a scalar field of the sort used by Jordan in his theory of the variable gravitational constant, a charged scalar particle field, and a vector particle field. A.

530.12 : 530.145

2171. A unified field theory with varying charge and rest-mass. H. C. CORBEN. *Nuovo Cimento*, **9**, 235–52 (*March*, 1952).

It is shown that the neutron and proton may be treated as different states of the one particle in a classical field theory by ascribing to them an extra degree of freedom in terms of which to specify the electric charge. This may be done in the framework of a unified field theory which is a modification of the theory of Kaluza and Klein. Kaluza's constant a being chosen to give the correct mass difference of neutron and proton. Without the explicit introduction of meson potentials or any free parameters, it then follows that there exists a short range ($\sim 10^{-13}$ cm) attraction between neutron and proton, and a modified Coulomb interaction between two protons. The possibility of charge exchange between nucleons is a consequence of the field equations and the geodesic equations of motion. A photon may acquire a charge and rest-mass when extremely close to a charged particle, and the possibility arises for the formation of systems of such charged photons with rest energies of order 100 MeV. Without any special assumptions about the fifth co-ordinate x^5 it follows that in the linear approximation the electromagnetic potentials satisfy Maxwell's equations and are independent of x^5 when all other potentials are neglected. Correspondence with classical electrodynamics is established in the limit $a \to 0$. A.

530.12 : 530.145

2172. On the general theory of relativity and unified field theory. F. CAP. *Acta phys. Austriaca*, **6**, *No.* 2–3, 135–56 (1952) *In German.*

A general review with particular reference to affine generalizations. R. A. NEWING

530.12 : 531.18

2173. On the physical interpretation of the Lorentz transformation. L. JÁNOSSY. *Acta phys. Hungar.*, **1**, *No.* 4, 391–422 (1952). *Ann. Phys.* [*Leipzig*] **11**, *No.* 4–7, 293–323 (1953) *In German.*

A local system K_0 is postulated in which light is propagated isotropically, uniform motion relative to K_0 involving Lorentz–Fitzgerald distortions of measuring rods and clocks. Such distortions are accounted for by assuming that a mechanical system in equilibrium in K_0 will take up a new equilibrium configuration when set moving uniformly relative to K_0. The velocity of light is regarded as the velocity of propagation of most physical actions, but not necessarily an upper limit for all possible actions. R. A. NEWING

530.12 : 531.18

2174. A quasi-relativistic theory of gravitation. M. G. MOORE. *Phys. Rev.*, **89**, 587–90 (*Feb.* 1, 1953).

Rays of gravitons, as well as rays of photons in a gravitational field, have transverse vibrations, and a light ray has its velocity decreased by the presence of a gravitational ray. The decrease is twice as much when they are travelling in the same direction as when they are perpendicular (and, therefore, share one dimension of vibration rather than two). Introduction of a harmonic function for the square of the velocity of light leads to Schwarzschild's equation for, first, a light ray, and then, by way of its electromagnetic field, for a particle of matter. If the sun is moving through the ether, the action of the field is relativistic, except that the angle between the light ray and the gravitational ray is measured with respect to the ether. The acceptance of Miller's ether drift data would lead, then, to perturbations of the planets, including the major part of that observed in the nodes of Venus. A.

530.12 : 538.3

2175. On the principle of least action and on the electromagnetic equations which may be deduced from it. I–II. B. FINZI. *R.C. Accad. Naz. Lincei*, **12**, 378–82 (*April*); 477–80 (*May*, 1952) *In Italian.*

In the conventional four-dimensional formalism the electromagnetic tensor satisfies the equations $\operatorname{curl} F = 0$ and $\operatorname{div} F = j$ where j is the electric distribution. Weyl (1917) proved that, assuming validity of the first law, the second may be obtained from a principle of least action. It is shown here that both laws can in fact be deduced from a single least action principle. The result is then extended to more general fields. L. PINCHERLE

530.145

2176. Markoff chains, Wiener integrals, and quantum theory. E. W. MONTROLL. *Commun. pure appl. Math.*, **5**, 415–53 (*Nov.*, 1952).

An expository article, applying methods developed for calculating certain Wiener function space integrals to the evaluation of function space integrals occurring in Feynman's Lagrangian formulation of quantum theory. The formal relations between Markoff chains and quantum processes are discussed in some detail.

R. H. DALITZ

530.145

2177. Classical and quantum field theories in the Lagrangian formalism. P. G. BERGMANN AND R. SCHILLER. *Phys. Rev.*, **89**, 4–16 (*Jan.* 1, 1953).

The relationship between the transformation properties of a (non-quantum) covariant field theory and its constraints, generating functionals, conservation laws and "superpotentials" purely within the Lagrangian formalism is examined and the relevance of these quantities for the problem of motion of particles (singularities) in the field indicated. This discussion includes a presentation of actual methods of computation of these important quantities suitable for a very wide class of theories. In the second part the probable structure of a quantum covariant field theory, both in the Hamiltonian and in the Lagrangian formalism, is discussed. In the Hamiltonian formalism, it is suggested that those field variables canonically conjugate to constraints are not observables in the physical sense nor operators in Hilbert space, and that the states of a system which alone can be regarded as Hilbert vectors are those consistent with all the constraints inherent in the theory and its transformation properties. This approach permits the characterization of legitimate observables even if the isolation of the "constraint variables" is not feasible, as in the general theory of relativity; observables must commute with all the constraints. They are, thus, invariants under the group of invariant transformations. It is asserted that this selection of observables, which is mathematically self-consistent, does not lead to the discard of quantities of physical interest. On the other hand, all the so-called paradoxes between constraints (subsidiary conditions) and commutation relations are thereby avoided. In the development of the Lagrangian quantization, a new set of field equations is proposed which are different from the usual ones but which can be shown to permit the transition to the canonical formulation if desired. The proposal is to assert the stationary character of the Feynman–Schwinger action operator not with respect to all, but only with respect to those variations that correspond to invariant transformations. As a result, the number of operator equations at each point of space-time is finite, though it is different from the number of equations in the non-quantum theory. These equations, though considerably weaker than what would be obtained if the action integral were to be made stationary with respect to all conceivable variations, are sufficient to yield all the usual conservation laws and also to permit the transition to the Hamiltonian form of the theory if desired. Commutation relations can be obtained for the field variables and their time derivations on the same hypersurface, simply by requiring that the field variables and their derivatives be algebraically independent of each other. The procedure employed breaks down if applied to a variable that is canonically conjugate to a constraint, an indication that in the Lagrangian formulation, too, the set of observables must be selected if paradoxes are to be avoided. Altogether it appears that the Lagrangian and the Hamiltonian quantizations, if set up properly, are largely equivalent; but this does not preclude the possibility that one may be more useful heuristically than the other.

A.

530.145

2178. The causal interpretation of quantum mechanics. S. T. EPSTEIN. Letter in *Phys. Rev.*, **89**, 319 (*Jan.* 1, 1953).

Points out that, following Bohm's proposal [Abstr. 2413–14 (1952)] a multiplicity of causal descriptions of quantum mechanics are obtainable, according to the representation used to express the Schrödinger equation, and that these causal descriptions are generally different.

R. H. DALITZ

530.145

2179. Comments on a letter concerning the causal interpretation of the quantum theory. D. BOHM. Letter in *Phys. Rev.*, **89**, 319 (*Jan.* 1, 1953).

Replies to the comments of Epstein (preceding abstract), giving reasons why the space-time description of physical phenomena is given preference in Bohm's interpretation of quantum mechanics.

R. H. DALITZ

530.145

2180. Proof that probability density approaches $|\psi|^2$ in causal interpretation of the quantum theory. D. BOHM. *Phys. Rev.*, **89**, 458–66 (*Jan.* 15, 1953).

In two previous papers [Abstr. 2413–14 (1952)] a causal interpretation of the quantum theory was developed which involved the hypothesis that a quantum-mechanical system contains a precisely defined particle variable $\mathbf{x}$ but that, at present, only the probability density ($P(\mathbf{x}, t)$ that the particle is at the position $\mathbf{x}$ can be calculated. It was shown that the assumption that $P(\mathbf{x}, t) = |\psi(\mathbf{x}, t)|^2$ is consistent, in the sense that if it holds initially, the equations of motion of the particles will cause this relation to be maintained for all time. In this paper the theory is extended to show that as a result of random collisions, an arbitrary probability density [illegible] Dirac[illegible] gradually decay into one with a density of $|\psi(\mathbf{x}, t)|^2$. Since all quantum-mechanical experiments to date have been concerned with statistical ensembles of systems that have been colliding with other systems for a very long time, it is therefore inevitable that as samples are drawn from such ensembles, the probability density of systems with particles at the point $\mathbf{x}$ will be equal to $|\psi(\mathbf{x}, t)|^2$. In the previous papers it was also pointed out that, within the conceptual framework of the causal interpretation, it was possible to suggest mathematical theories more general than are permitted by the usual interpretation and that these more general theories might be needed in the domain of 10^{-13} cm, where present theories seem to fail. However, if these more general theories should apply at

the level of 10^{-13} cm, then there would be a tendency to create discrepancies between P and $|\psi|^2$, a tendency whose cumulative effects should be felt even at the atomic level, where the more general theory ought to approach the usual theory. However, because those discrepancies have been shown to die out as a result of collisions, it can be expected that under normal conditions the difference between P and $|\psi|^2$ would be negligible. Conditions are suggested, however, in which this difference might be appreciable, and experiments are indicated which might be able to test for the existence of such discrepancies. A.

530.145

2181. Quantum theory. D. Bohm. *New York, Prentice-Hall*; *London, Constable* (1952) ix + 646 *pp.* Review in *Nature* [*London*] **171,** 276 (*Feb.* 14, 1953).

530.145 : 530.12

2182. Strong conservation laws and equations of motion in covariant field theories. J. N. Goldberg. *Phys. Rev.*, **89,** 263–72 (*Jan.* 1, 1953).

The relationship between the covariance of a field theory and the equations of motion is discussed in both the Lagrangian and the Hamiltonian formalism. All theories whose field equations are derivable from a variational principle and are covariant under arbitrary (curvilinear) co-ordinate transformations possess Bianchi identities and, hence, "strong" conservation laws. Because the strong conservation laws are ordinary divergences equal to zero, whether or not the field equations are satisfied, there exist certain skew-symmetric expressions whose divergences yield the components of the energy-momentum tensor. These superpotentials, as the skew-symmetric expressions are called, enable the energy and momentum content of the field to be written as two-dimensional surface integrals. Also, by using the superpotentials together with the field equations, one can find certain surface integrals which are independent of the surface of integration and which yield the equations of motion for the singularities enclosed by the surface. If the Einstein–Infeld approximation method is applied in the general theory of relativity, the above surface integrals reduce to integrals which are equivalent to those used by Einstein and Infeld to obtain the equations of motion for the field sources. In the Hamiltonian formalism the covariance of the theory is revealed in the existence of a number of constraints between the momenta and the field variables. Therefore, the relationship between the constraints and the Bianchi identities, which lead to the strong conservation laws, is examined and it is found that the first time derivative of the constraints leads to the existence of four linear combinations of field equations which are free of the time derivatives of the canonical field variables. These four expressions are the "secondary" constraints. The second time derivative of the primary constraints leads to the Bianchi identities in terms of the canonical field variables. Thus the existence of the strong conservation laws in the Hamiltonian formalism and, by the same arguments as in the Lagrangian formalism, the existence of the super-potentials can be established. The super-potentials are written out only for the gravitational theory. A.

530.145

2183. Mathematical aspects of the quantum theory of fields. IV. K. O. Friedrichs. *Commun. pure appl. Math.*, **5,** 349–411 (*Nov.*, 1952).

For Pt III, see Abstr. 4912 (1952). Two types of occupation number representations of a field, valid for the continuous case, are introduced. One of these is not necessarily equivalent to the particle representation of the field and can therefore apply to fields not possessing a vacuum state, for which case it is shown that expectation values, etc., may still be calculated. However the other representation is that apparently realized in nature. Finally it is shown how these and earlier considerations may be carried over to fermion fields. R. H. DALITZ

530.145

2184. Primitive quantization in the relativistic two-body problem. J. L. Synge. *Phys. Rev.*, **89,** 467–71 (*Jan.* 15, 1953).

A pair of events, one for each of two particles, is regarded as a point in 8-space (V_8). The technique of Hamilton's optical method is applied to V_8, giving rays and associated de Broglie waves. These waves are quantized by associating a phase-cycle with an increase if h in the characteristic function, and hence quantum rules appear as resonance conditions on the de Broglie waves, when the part of V_8 occupied by rays is multiply connected. A Hamiltonian equation is written down, the interaction between the particles being taken to be of Coulomb form, but with ordinary distance replaced by Minkowskian separation. This leads without approximation to a simple expression for quantized proper energies of the system, and from this expression follow the correct approximate energy levels for the hydrogenic atom (with Z_α) the mass-correction factor being included. There is no approximation based on smallness of relative velocity or ratio of masses, and mathematical complexities associated with retarded potentials are avoided by the use of the relativistic Coulomb interaction. A.

530.145 : 536.7

2185. Thermodynamics of some special fields. R. V. Krotkov and A. E. Scheidegger. *Canad. J. Phys.*, **31,** 329–36 (*Feb.*, 1953).

The free energy, internal energy, and entropy of two quantized fields are calculated, using the method introduced by Scheidegger and McKay. The two fields examined are those representing (*a*) an ensemble of mesons bound by an interaction with their source (a nucleon), and (*b*) an ensemble of electrons perturbed by an external electromagnetic field. The presence of a source in the first case is found to have no effect on the thermodynamic functions of the mesons, while an external electromagnetic field does affect the thermodynamic functions of the electrons. Explicit formulae in the latter case are given. A.

530.145

2186. Report on the recent development of quantum electrodynamics. II–III. K. Baumann. *Acta phys. Austriaca*, **6,** *No.* 1, 53–70; *No.* 2–3, 195–208 (1952) *In German.*

For Pt I, see Abstr. 7036 (1952). The survey of modern techniques for the elimination of divergencies is extended to cover the theories of Feynman and Dyson. R. A. NEWING

530.145

2187. Real and virtual processes in quantum electrodynamics. J. HAMILTON. *Proc. Cambridge Phil. Soc.*, **48**, *Pt IV*, 640–51 (1952).

The contribution from coincident singularities occurring in the integrands of matrix elements and responsible for non-analytic behaviour of the *S*-matrix [Eden, Abstr. 2412 (1952)], can be separated off and the coincident singularities can be classified graphically. Any Feynman or Dyson graph can be expressed as the sum of graph parts corresponding to a particular coincidence or lack of coincidence of singularities. The only coincidences of importance correspond to real (as distinct from virtual) graph parts describing two or more successive physical processes; they can be expressed in terms of constituent virtual parts. Using also the concept of the external part of a graph (arising from a diagonal element of the *S*-matrix) the unitary nature of the theory is demonstrated for a simple case, and the relation between the unitary condition and the convergence of the *S*-matrix expansion is briefly considered. Finally, it is shown how any matrix element can be expanded in terms of the virtual graph parts by means of an integral equation whose form makes the unitary condition obvious.

W. A. HEPNER

530.145

2188. Note on the concept of vacuum in quantum electrodynamics. F. A. KAEMPFFER. Note in *Canad. J. Phys.*, **31**, 165–6 (*Jan.*, 1953).

The possibility of the exchange energy of the vacuum electrons cancelling their zero-point kinetic energy is considered. W. A. HEPNER

530.145

2189. The canonical transformation for an electron-positron field coupled to a time-independent electromagnetic field. H. E. MOSES. *Phys. Rev.*, **89**, 115–22 (*Jan.* 1, 1953).

The problem of the electron-positron field coupled to an unquantized electromagnetic field, constant in time, is solved in the Schrödinger picture by finding a suitable canonical transformation. It is shown that in the number representation this transformation satisfies an integro-difference equation which can be solved by means of a perturbation scheme in a manner analogous to the finding of one-particle canonical transformations. It is shown, moreover, that this canonical transformation can be expressed in terms of single particle canonical transformations. A.

530.145 : 538.3

2190. Gauge invariance and classical electrodynamics. L. MOTZ. *Phys. Rev.*, **89**, 60–77 (*Jan.* 1, 1953).

A Lagrangian for deriving the Maxwell–Lorentz field equations is obtained by starting from a general tensor of the second rank $\mathcal{G}_{\mu\nu}$, which is expressed as the sum of a symmetric and an antisymmetric part $\mathcal{G}_{\mu\nu} = \lambda g_{\mu\nu} + F_{\mu\nu}$. The symmetric part is identified with the metric tensor and the antisymmetric part with the electromagnetic field. A relationship between this second rank tensor and the gauge-invariant Ricci–Einstein tensor is established by means of the gauge-invariant theories of Weyl and Eddington. This relationship leads directly to the Klein–Gordon relativistic wave equation for a point charge moving in an electromagnetic field provided the function λ is properly chosen. The Lagrangian density is defined as the quantity $(-|\mathcal{G}_{\mu\nu}|)^{\frac{1}{2}}$, where $|\mathcal{G}_{\mu\nu}|$ is the determinant associated with the tensor $\mathcal{G}_{\mu\nu}$. This choice is made for the Lagrangian density since $(-|\mathcal{G}_{\mu\nu}|)^{\frac{1}{2}}d\tau$ is the simplest generalized invariant volume element. Since the Lagrangian density is non-linear and irrational as it stands, it is first rationalized by means of the Dirac matrices. If the Lagrangian that is obtained in this way is varied with respect to the vector and scalar potentials, one obtains a set of Maxwell–Lorentz equations for a charge-current distribution that is defined in terms of the field potentials. These equations are almost identical with those recently obtained by Dirac in his new classical electrodynamics. It is shown from the field equations that the velocity of the charge distribution is given by the relation $\mathbf{v} = (\mathbf{A}/\phi)c$, where $\mathbf{A}$ is the vector potential, ϕ is the scalar potential, and c is the speed of light. This is identical with the result obtained from the retarded potentials of a point charge. For the static case it is shown that the field equations lead to solutions for the fields and potentials that are finite everywhere, and the self energy of the point charge is finite. The classical radius of the electron, the Compton wavelength and the fine structure constant come into the theory quite naturally. A.

530.145

2191. Circulation in the flow of electricity: Dirac's new variables. O. BUNEMAN. *Proc. Roy. Soc. A*, **215**, 346–52 (*Dec.* 5, 1952).

Kelvin's circulation theorems are shown to be applicable to the generalized momentum vector in the relativistic flow of electricity. Vortex filaments become "vortex ribbons" in space-time and Dirac's variables ξ and η are identified as the parameters which characterize the family of vortex ribbons. The physical reality of discrete ribbons of strength $\hbar$ is suggested, speculatively. A.

530.145

2192. Conversion of an amplified Dirac equation to an approximately relativistic form. W. A. BARKER AND Z. V. CHRAPLYVY. *Phys. Rev.*, **89**, 446–51 (*Jan.* 15, 1953).

A fermion is described by a one-body relativistic wave equation of the Dirac type in which scalar, vector, tensor, pseudovector and pseudoscalar interactions are included phenomenologically. This equation is converted to an approximately relativistic form by means of the Foldy–Wouthuysen transformation. The resulting relativistic correction terms associated with the five types of interaction are tabulated. The tables may be used to convert any one-body Dirac equation to its corresponding approximately relativistic form. The fine structure of the hydrogenic atom including the Lamb–Retherford shift is discussed as an illustration. A.

530.145

2193. Bound-state perturbation theory in four-dimensional momentum representation. G. E. BROWN. *Proc. Roy. Soc., A*, **215**, 371–85 (*Dec.* 5, 1952).

A 4-dimensional perturbation theory for bound-state problems is developed here. It is shown that

modified S-matrix techniques and graphical methods can be applied to bound-state problems. The correspondence of this theory to the ordinary perturbation theory is discussed, and by way of illustration, the 4-dimensional theory is applied to the calculation of energy corrections from the exchange of 2 transverse photons by the electron and proton in H. This exchange is found to contribute only to the fine-structure and not to the spin-spin interaction in the first order it enters, $\alpha^3(m/M)\boldsymbol{R}$. A.

530.145

2194. On the evaluation of the Coulomb scattering cross-section for the collision of two elementary particles of spins $n\hbar/2$ and $m\hbar/2$ (m, n integral). G. PETIAU. *C.R. Acad. Sci.* [*Paris*] **235**, 1612–14 (*Dec.* 22, 1952) *In French.*

The scattering cross-section is calculated covariantly for distinguishable particles described by the author's theory of particles of arbitrary spin [Abstr. 6285 (1952)] and interacting through the e.m. field.

R. H. DALITZ

530.145

2195. On the concept of the effective range in the theory of the scattering of nucleons on nuclei. T. SEXL. *Acta phys. Austriaca*, **6**, *No.* 1, 30–4 (1952) *In German.*

An expression for the effective range is derived from the theory of Guth and Sexl (1930).

W. J. SWIATECKI

530.145

2196. On a convergent meson theory. I. P. KRISTENSEN AND C. MØLLER. *K. Danske Vidensk. Selsk. mat.-fys. Medd.*, **27**, *No.* 7, 51 *pp.* (1952).

A non-local interaction between nucleons and pseudoscalar mesons, containing a covariant form factor $F(x', x'', x''')$ is studied. The S-matrix is calculated following Bloch (abstract following) and the properties of F implied by relativity, reality, finiteness of 2nd-order particle self-energies, and correspondence to the usual theory for distances large compared with a given λ are discussed. Only for high momentum transfers does this S-matrix differ appreciably from the usual theory; the finite particle self-energies are shown to be small. Differences between this and the usual local theory are emphasized; a group of "quasi-canonical" transformations is introduced and shown to leave the S-matrix invariant. Vacuum polarization by a time-like external meson field is shown to be finite. R. H. DALITZ

530.145

2197. On field theories with non-localized interaction. C. BLOCH. *K. Danske Vidensk. Selsk. mat-fys. Medd.*, **27**, *No.* 8, 55 *pp.* (1952).

Studies particularly non-local theories with an interaction term $\int F(x', x'', x''')\bar{\psi}(x')\phi(x'')\psi(x''')\,dx'dx''dx'''$. The restrictions on F necessary to ensure that the theory reduces to the usual local theory for distances greater than a given λ are investigated; their relation with regularization is discussed. Assuming this interaction to be zero outside a finite region, conservation laws are deduced, leading to the usual collision constants. Commutation relations are defined for the asymptotic field variables and the S-matrix is obtained by a generalization of the Yang–Feldman method—direct application of Feynman formalism is incorrect here as it leads to a non-unitary S-matrix. Particles self-energies are finite to 2nd order, but some divergences still remain in general. It is shown how e.m. interaction may be introduced in gauge-invariant manner in a non-local theory. R. H. DALITZ

530.145

2198. Symmetry requirements in electron scattering by an atom. L. E. H. TRAINOR AND T.-Y. WU. *Phys. Rev.*, **89**, 273–4 (*Jan.* 1, 1953).

It is pointed out that in the treatment of the problem of electron scattering by an atom including the effect of the Pauli principle, the use of unsymmetrized wave function and asymptotic conditions in one electron does not ensure the required asymptotic conditions in the other electron. However, the use of symmetrized wave functions automatically ensures symmetrical asymptotic conditions in both electrons. A.

530.145

2199. Validity of Born approximation in stripping. N. AUSTERN. Letter in *Phys. Rev.*, **89**, 318–19 (*Jan.* 1, 1953).

The omission of matrix elements of the interaction potential between the neutron and proton of the deuteron is implied both by S. T. Butler's method and the Born approximation, and this accounts for the close agreement of the two treatments.

W. J. SWIATECKI

530.145

2200. On the theory of the subtractive field and the mass spectrum of mesonic particles. C. MARTIN. *C.R. Acad. Sci.* [*Paris*] **236**, 53–5 (*Jan.* 5, 1953) *In French.*

With the hypothesis that the meson masses are $137im_e$ ($i = 2, 3 \ldots n$) the corresponding meson-electron coupling constants required by de Broglie's theory of subtractive fields [Abstr. 4910 (1952)] are calculated. R. H. DALITZ

530.145

2201. Variational principles for three-body scattering problems. S. BOROWITZ AND B. FRIEDMAN. *Phys. Rev.*, **89**, 441–5 (*Jan.* 15, 1953).

Several stationary expressions for the direct and the exchange scattered amplitudes in three-body collisions are derived. A.

530.145

2202. New approach to the problem of higher order corrections in the meson theory of nuclear forces. J. WERLE. Letter in *Phys. Rev.*, **89**, 529 (*Jan.* 15, 1953).

The procedure of expansion according to orders of (d/dt) [Einstein *et al.* (1938), J. Werle, Abstr. 7048 (1952)] is outlined for general quantum mesodynamics and illustrated on a simple transition matrix element. Higher orders in g^2 appear inseparably with relativistic corrections. The equivalence of ps. vector and ps. scalar couplings also follows easily. W. J. SWIATECKI

530.145

2203. Pion-nucleon scattering when the coupling is weak and extended. G. F. CHEW. *Phys. Rev.*, **89**, 591–3 (*Feb.* 1, 1953).

The symmetrical pseudoscalar meson theory, with an extended pseudovector coupling to the nucleon

and neglect of nucleon recoil effects, is shown to be capable of explaining the existing data on the *P*-wave pion-nucleon scattering. The required sizes of the source radius and coupling constant correspond to a relatively weak pion-nucleon coupling, but reactive effects in the scattering are nevertheless so important that the lowest order approximation in a perturbation treatment is completely inadequate. The Dancoff approximation, on the other hand, is accurate to within 10 or 20%. A.

530.145

2204. The symmetry of the *S* matrix. F. COESTER. *Phys. Rev.*, **89**, 619–20 (*Feb.* 1, 1953).

It is provided that any Heisenberg *S*-matrix is symmetric for an appropriate choice of arbitrary phases in a representation in which the square and one component of the total angular momentum are diagonal. The consequences of this symmetry for the complex phases of the matrix elements are discussed. A.

530.145

2205. Three-nucleon interactions in Yukawa theory. G. WENTZEL. *Phys. Rev.*, **89**, 684–8 (*Feb.* 15, 1953).

The method of Salpeter and Bethe is applied to the three-nucleon bound state problem. In a first approximation involving only multiple ladder-type diagrams, and neglecting retardation effects altogether, an equivalent Hamiltonian is derived which contains as potential energy merely the static Yukawa potentials of the three nucleon pairs. If the retardation corrections are treated as small perturbations, e.g. in a scalar theory, the resulting three-particle interactions prove to be small of the second order, and no larger than those deriving from other classes of Feynman diagrams. Appendices give the static solution of the four-particle problem, and the first-order retardation correction to the two-body potentials for scalar theories. A.

530.145

2206. Multiple scattering corrections to the impulse approximation in the two-body system. K. A. BRUECKNER. *Phys. Rev.*, **89**, 834–8 (*Feb.* 15, 1953).

Exact solutions for the scattering of a fast particle by two heavy scatterers are obtained and compared with the usual treatment of the impulse approximation in which multiple scattering is neglected. It is found that the multiple scattering qualitatively changes the solution except in the extreme Born approximation limit. The methods developed are applied to the isotopic spin dependent, but spin independent, scattering of mesons in the deuteron. It is found that if high-energy scattering is assumed to be in the isotopic spin $\frac{3}{2}$ state, a considerable depression in the total cross-section can be expected for phase shifts larger than 45 degrees. A.

530.145 : 539.185

2207. Multiple scattering and radiation damping. II. H. EKSTEIN. *Phys. Rev.*, **89**, 490–501 (*Jan.* 15, 1953).

For Pt I, see Abstr. 7535 (1951). The analysis of multiple elastic scattering by a system of fixed scatterers in terms of two-body collision matrices is extended to large bodies. The dynamical theory of particle wave propagation in crystals is formulated and discussed from this viewpoint, as an extension of Ewald's theory to scatterers of finite size. A theory of wave propagation in a random medium, including disordered crystals, is obtained as the limiting case for a crystal with infinite unit cell. Contrary to the usual approach, this analysis considers a definite "frozen" configuration of the medium; statistical averaging over configurations may be used on the intensities obtained. In crystals and dense liquids, radiation damping is compensated by the reaction of surrounding scatterers. Therefore, it is found convenient to restate the basic equations of multiple scattering in terms of a matrix β which is essentially the Green's function for the single scattering event, with "standing wave" rather than "outgoing wave" boundary conditions. This has the advantage of eliminating the spurious radiation damping terms at the outset; one obtains non-attenuated waves in nondissipative crystals or dense liquids by a simple expansion method. Application is made to the following problems: the equivalent of the Lorentz–Lorenz formula for matter waves; index of refraction for an interaction of the form of a one-level Breit–Wigner formula; attenuation of long waves in a disordered crystal containing protons with random spins; double refraction effect in a liquid or crystal containing protons with partially oriented spin. A.

530.145

2208. On the number of bound states in a central field of force. V. BARGMANN. *Proc. Nat. Acad. Sci. U.S.A.*, **38**, 961–6 (*Nov.*, 1952).

The number of bound state solutions of the radial wave equation $\phi'' - l(l+1)r^{-2}\phi + E\phi = V(r)\phi$ is shown to be $< (2l+1)^{-1}\int_0^\infty r|V(r)|dr$. R. A. NEWING

530.145

2209. Certain explicit relationships between phase shift and scattering potential. N. LEVINSON. *Phys. Rev.*, **89**, 755–8 (*Feb.* 15, 1953).

An intuitive account is given of recent important results of Gelfand and Levitan for the determination of the potential in the one-dimensional Schrödinger equation from the *S*-phase shift, the bound states and certain normalizing parameters. The method is then used to obtain the first variation in the potential corresponding to a small change in the phase shift, bound states and normalizing parameters. A.

530.162

2210. Brownian motion in the theory of irreversible processes. R. T. COX. *Rev. mod. Phys.*, **24**, 312–20 (*Oct.*, 1952).

An adaptation of Gibbs' method, previously used to discuss the theory of irreversible processes [Abstr. 274 (1951)], is used to treat some of the problems of Brownian motion, and many of the standard results are rederived in this way. E. H. SONDHEIMER

530.162 : 536.77

2211. The temperature variation of the thermodynamic potential of a degenerate electron gas. K. S. KRISHNAN AND P. G. KLEMENS. Letter in *Phil. Mag.*, **43**, 1224–5 (*Nov.*, 1952).

It is pointed out that a distinction must be made between the cases of constant electron density and

constant pressure, and it is shown that the specific heat of a highly degenerate electron gas at constant pressure is the same as that at constant volume.

E. H. SONDHEIMER

GENERAL MECHANICS . MECHANICS OF SOLIDS 531

531.224 : 534.01

2212. Application of Dirac's δ-function to some problems in classical physics. L. S. KOTHARI. *Amer. J. Phys.*, **21**, 99–101 (*Feb.*, 1953).

The Dirac δ-function is used in solving the problem of bending of a beam and also some problems of vibration. It is seen that fairly general results can be obtained without complicated calculations. A.

531.231

2213. Computation of the moment of inertia of various bodies by the approximate sum of numerical series. E. ORTIZ MUÑIZ. *Amer. J. Phys.*, **21**, 11–14 (*Jan.*, 1953).

Presents a simple method of computing moments of inertia of various bodies by approximating the sum of numerical series. The method lends itself to be used in a course of college physics where most students are not familiar with calculus. A.

531.31

2214. The closed differential pulley: analysis of its rotational and linear motions. L. E. DODD. *Amer. J. Phys.*, **21**, 112–23 (*Feb.*, 1953).

A mechanical system of special design, primarily for instructional purposes, is proposed, mathematically analysed and tested experimentally. It may be regarded as a hybrid form between the compound wheel-and-axle and the differential pulley or chain hoist. Although the design is simple, the analysis is not too obvious at the start, and is somewhat complicated, exhibiting coordinated angular and linear motions with constant accelerations due entirely to the weight of the movable pulley. While the analysis assumes no friction, the actual heat loss can be readily calculated from time and displacement measurements and the equivalent friction force determined. Numerous equations and numerical data are included. The system offers various challenges to student interest in classical mechanics, both on the lower-division and advanced levels. Particular experimental work is suggested and analytical exercises given for use by teachers. A.

531.383 : 539.62

2215. On tops rising by friction. N. M. HUGENHOLTZ. *Physica*, **18**, 515–27 (*Aug.–Sept.*, 1952).

First an explanation is given of the unexpected behaviour of the so-called "tippetop" or "toupie magique." On a perfectly smooth plane the top appears not to turn over. But it does as soon as there is some friction. The behaviour appears to be strongly dependent on the eccentricity of the mass centre and on the relative difference of the moments of inertia. Finally an explanation is suggested for the rising of an ordinary top. A.

531.383 : 539.622

2216. The tracks of tops' pegs on the floor. A. D. FOKKER. *Physica*, **18**, 497–502 (*Aug.–Sept.*, 1952).

The mechanism of the reaction of the floor through the peg on a top's motion is studied by obtaining the peg's track. Pegs were fashioned in special ways and the tracks are shown. There always is an initial state of slipping adjustment to a state of rolling. Some reflections are offered on the mechanism of rolling friction. A.

531.383 : 539.622

2217. On the influence of friction on the motion of a top. C. M. BRAAMS. *Physica*, **18**, 503–14 (*Aug.–Sept.*, 1952).

A simple calculation gives, to a first approximation, the influence of sliding friction on the motion of a top, spinning on a horizontal plane. For a spherical body with axially symmetric mass distribution two effects are found: (1) The centre of gravity will be lifted if it lies eccentric in the sphere; (2) the axis with the greatest moment of inertia moves towards the vertical, if the principal momenta are unequal. The equilibrium condition for the combination of the two effects is derived. The rising of the tippe top is ascribed to sliding friction. An ordinary top, describing its common regular precession, will usually roll; rolling friction contributes to the rising of the top. A.

531.532

2218. Possible motions of a sphere suspended on a string (the simple pendulum). J. V. HUGHES. *Amer. J. Phys.*, **21**, 47–50 (*Jan.*, 1953).

The possible motions of a sphere suspended on a string are found to consist of combinations of (1) a pendulum type of motion and (2) a rolling motion, in which the ball rolls in angular harmonic motion about an axis very near its centre. For (1) it is shown (*a*) the usual formula for the length of the equivalent simple pendulum should be replaced by $L(1 + 2r^2/5L^2 + 4r^3/25L^3 + \ldots)$, where r is the radius of the ball and L the distance of point of suspension to centre of the sphere, and (*b*) the best way of starting this motion is to pull the ball aside by a horizontal force through its centre. For (2) it is shown that the period of oscillation is very close to $2\pi\sqrt{(2r/5g)}$. Photographs are given showing experimental verifications of these effects. A.

531.55

2219. Two ballistics problems of future transportation. W. A. ALLEN. *Amer. J. Phys.*, **21**, 83–9 (*Feb.*, 1953).

Two ballistics problems that may arise in future transportation have been formulated and solved in detail. The first problem is that of a vehicle moving along a great circle of the earth; the second problem is that of a rocket moving radially away from the earth. In both cases the magnitude of the resultant acceleration applied to the body has been set equal to a constant. The value of this acceleration will be determined ultimately by the maximum acceleration that human beings or material objects can withstand. A.

MECHANICAL MEASUREMENTS 531.7

531.715.1

2220. Method for comparing an end-gauge and a slip-gauge. J. TERRIEN. *C.R. Acad. Sci.* [*Paris*] **235,** 1288–90 (*Nov.* 24, 1952) *In French.*

The use of transparent parallel-plane glass or silica end-blocks, the thicknesses of which are determined by interference, is proposed and the advantages are detailed. S. WEINTROUB

531.717.3 : 621.317.79

2221. A linear transducer for the electrical measurement of displacement. M. J. TUCKER. *Electronic Engng*, **24,** 420–2 (*Sept.*, 1952).

This device depends upon the change in coupling between two coils with linear displacement. The primary is wound round the centre limb of a stack of Permalloy gate stampings. It extends almost halfway up this limb and above it is located the movable secondary coil. This latter coil is connected through a bridge rectifier to a d.c. indicating instrument. Over the linear operating range, corresponding to a displacement of approx. 1 cm, the output current varies from 1·3 to 2·7 mA. Accordingly, sensitivity can be improved by backing off some of this current, and two circuits intended for this purpose are shown. The circuit as used has to work off a 250 c/s supply, but the advantages of a higher frequency, e.g. 2 kc/s, are pointed out. Over the 1 cm range, linearity within the accuracy of measurement, approx. 0·005 cm, is achieved. H. G. M. SPRATT (R)

531.717.3 : 621.385.2 : 621.317.79

2222. Electronic measuring instrument for small displacements. L. A. GONCHARSKIĬ. *Elektrichestvo*, **1952,** *No.* 6, 62–5. *In Russian.*

The theory of the input diode of a thermionic measuring instrument for small mechanical displacements using a moving electrode is presented. A method for determining the current and voltage sensitivities of the instrument is found. It is seen that a diode with flat parallel electrodes is the most sensitive input element for such purposes, as far as current sensitivity is concerned, whereas the possibilities for improving voltage sensitivity are rather limited. B. F. KRAUS (R)

531.743

2223. An angle comparator for laboratory use. H. LLOYD, A. T. F. SIMMONS AND G. E. WINDER. *Safety Mines Res. Establ. Res. Rep., No.* 37, 12 *pp.* (*June*, 1952).

The instrument is primarily for use in experimental researches on explosives for improving the accuracy and ease of measuring photographic film records of detonation speeds. The optical principles and construction are described, and an analysis is given of its performance. A.

531.753 : 531.758 : 621.318.3 : 621.317.49

2224. Magnetic weighing and gas-density balances. J. H. SIMONS, C. L. SCHEIRER, JR AND H. L. RITTER. *Rev. sci. Instrum.*, **24,** 36–42 (*Jan.*, 1953).

A design is given for an electromagnetic device that can be employed instead of weights or springs for weighing purposes. In this particular design the balancing current is linear with the force applied to the arm of the balance so that current measurement gives a direct reading of weight. A capacity null-point indicator is also described and so also are electrical circuits that enable this null-point indicator to automatically operate the electromagnet. These auxiliaries are shown incorporated in a density balance. This balance was sensitive to a change of weight of better than 10^{-7} g or in terms of oxygen pressure at room temperature to 0·02 mm of Hg. The designs of density balances are discussed. A.

531.791 : 539.215.4

2225. Automatic particle-sizing by successive countings. P. G. W. HAWKSLEY. Letter in *Nature* [*London*] **170,** 984–5 (*Dec.* 6, 1952).

In automatic photoelectric sizing of particles dispersed on microscope slides the size is usually determined from measurements of pulse-heights or pulse-lengths. It is pointed out that sizing can also be made by recording the number only of the pulses, and various methods, for example, with a variable scanning aperture, or, for use with the "flying spot microscope" [Abstr. 3473 (1951)], two scanning spots at a variable distance apart, are discussed. One detecting device need only be used in the latter method and the theoretical treatment of this case is outlined. S. WEINTROUB

MECHANICS OF FLUIDS 532

532.13 : 541.182.025

Effect of shear temperature on viscosity in a rotational viscometer measurement. *See Abstr.* 2791

532.13 : 666

2226. Viscosity of glass. W. CAPPS. *J. Colloid Sci.*, **7,** 334–42 (*June*, 1952).

A review is presented of some methods for measuring viscosity and of some of the work of various authors in relating their data to the structure of glass and to the size of the units participating in the flow process. The range of measurements covers from about 10^2 poises to about 10^{15} poises at temperatures up to 1400°C. An outline is presented of some attempts which have been made to extend the kinetic theory of gases and solid-state theories to the liquid state. The relative importance of ionic size and interionic binding forces in various temperature ranges is discussed for some binary alkali silicates. Evidence is given that many glasses are Newtonian liquids in both high and low viscosity ranges. A.

532.133/.137

2227. On a new measurement of the viscosity of water. F. HÖPPLER. *Z. angew. Phys.*, **4,** *No.* 8, 297–300 (1952) *In German.*

A new type viscometer is described in which the time of oscillation of a sphere in water is measured and compared with that in air. A value of 1·008 cp at 20°c is obtained and an accuracy of ±0·1% claimed. T. C. TOYE

532.137

2228. A vibrating-plate viscometer. J. G. WOODWARD. *J. Acoust. Soc. Amer.*, **25**, 147–51 (*Jan.*, 1953).

When a thin, flat plate executing linear oscillations in its own plane is immersed in a liquid, shear waves are set up in the liquid, and the liquid exerts a retarding force on the plate. This force, which can be measured by means of an electromechanical transducer to which the vibrating plate is coupled, is a function of the product $\eta\rho$ of the coefficient of viscosity and the density of the liquid. Electrical measurements thus permit a computation of the value of $\eta\rho$. A viscometer which operates on this principle and is simple in both construction and use is described. This instrument gives instantaneous indications of $\eta\rho$ over a wide range and also permits continuous indications of $\eta\rho$ as a function of time to be made. A theory based on the impedance offered to an infinite vibrating plate by a liquid in which it is immersed is shown experimentally to give a valid, approximate description of the performance of the vibrating-plate viscometer in its practical form. A.

532.5

2229. On fluid dynamics in physics teaching. R. J. SEEGER. *Amer. J. Phys.*, **21**, 29–46 (*Jan.*, 1953).

First, general physics is examined. A critical analysis is made in particular of the important Bernoulli theorem as to what it is, what it says, what it means and how it is used. In the case of theoretical physics the motion of a sphere has been selected. The typical course is compared with experimental observations, particularly those in wind tunnels and in ballistics ranges. In conclusion, questions are noted on the foundations of fluid dynamics, particularly the role of viscosity, turbulence, the concept of a steady state and the role of heat. A.

532.51 : 532.54

2230. Definition and properties of inert flows. J. LE FOLL AND M. KADOSCH. Note in *Rev. sci.* [*Paris*] **90**, 137 (*March–April*, 1952) *In French.*

In the case of variable, unidimensional, isentropic flow in a pipe of varying cross-section, the possibility is established, mathematically, of the existence of a type of flow characterized by no work being done in compressing the fluid and no occurrence of wave propagation, the pipe offering no resistance to flow of fluid. This type of flow occurs in a region separating one in which the fluid is compressed from one in which the fluid expands. Pressure and density remain const. at all points, and the discharge $D(t)$ is a function of t alone. By suitable choice of the origin of abscissae, the equations of inert flow take the form $s = \omega/x$, $D = \omega/t$ and $u = x/t$, ω being a homogeneous const. J. S. G. THOMAS

532.51 : 532.54

2231. Inert flow expressed in Lagrange variables. M. KADOSCH. *Rev. sci.* [*Paris*] **90**, 138–9 (*March–April*, 1952) *In French.*

Inert flow, defined in the preceding abstract, is expressed in terms of Lagrange variables, and conditions for three types of flow in which the discharge is a function of time alone are briefly discussed. For a perfect gas, these three flow types can be derived by combining, in pairs, 3 very simple equations, and can be summarized in the relation $\partial\psi/\partial\phi = \pm u/c = \pm M$, where M denotes the Mach number of the flow. Alternately, the work of compression being zero, the flows discussed can be termed "pure transfers." J. S. G. THOMAS

532.517.4 : 538.69

2232. On the equations of isotropic turbulence in magneto-hydrodynamics of compressible medium. M. Z. E. KRZYWOBLOCKI. *Acta phys. Austriaca*, **6**. *No.* 2–3, 157–66 (1952).

Previous work by Chandrasekhar [Abstr. 1646, 6774 (1951)] is extended to take account of the finite compressibility of the medium. E. P. WOHLFARTH

532.527

2233. Formation of a vortex ring by giving an impulse to a circular disk and then dissolving it away. G. I. TAYLOR. Letter in *J. appl. Phys.*, **24**, 104 (*Jan.*, 1953).

A flat circular disk, of radius c, suddenly moved forward with velocity U along the axis of symmetry in a perfect fluid, without separation of flow, and then suddenly annihilated develops a distribution of circular vortex lines over the plane of the disk. The total strength of the vortices in the circular plane annulus between r and $r + dr$ is $4Ur(1 - r^2/c^2)^{-\frac{1}{2}}dr/\pi c$. Vortex lines, where they are strongest in the part of the sheet, near the edge, tend to roll up the weaker parts near the centre, round them, so that the vorticity tends to concentrate inside a ring. On the assumption that the vorticity in this ring becomes nearly constant inside a circle of radius a, i.e. that the vorticity is distributed in a core of mean radius R and radius of cross-section a, values of the three parameters of the vortex ring, viz. a, R and V' the velocity of the ring are determined in terms of U and c. J. S. G. THOMAS

532.527

2234. Formation of vortex streets. G. BIRKHOFF. *J. appl. Phys.*, **24**, 98–103 (*Jan.*, 1952).

It is shown that, for vortex trails in a nonviscous fluid, the mean longitudinal spacing a and mean transverse spacing h are invariant. It follows from this and other known facts, that the periodicity of a vortex trail is unstable, not the ratio h/a. In a viscous fluid, a is invariant but h increases. This fact explains various known experimental observations. A rough explanation is given for the order of magnitude of the Strouhal number S, based on the inertia opposed by the wake to transverse oscillations. Finally, using the theory of logarithmic potential, it is shown that, even in a nonviscous fluid, the concentration of vorticity is limited to circles whose diameter is about $a/4$. A.

532.593

2235. The generation of waves by wind. J. DARBYSHIRE. *Proc. Roy. Soc. A*, **215**, 299–328 (*Dec.* 5, 1952).

Describes an investigation of the height and length of ocean waves and swell in relation to the strength, extent and duration of the wind in the generating area, and the subsequent travel of the swell through calm and disturbed water. The investigation is based on records of waves made on the north coast of

Cornwall, in the Irish Sea and in Lough Neagh. It is a practical continuation of the work of Barber and Ursell (1948), who showed that the waves leaving the generating area behave as a continuous spectrum of component wave trains which travel independently with the group velocities appropriate to their periods. The spectral distribution of energy in the storm area is considered, and the relative amplitudes of the different components are deduced empirically under various wind conditions. The results indicate that the wave characteristics become practically independent of fetch after 200 to 300 miles, and that in the equilibrium condition the steepness of the highest waves is inversely proportional to the square root of the wind speed. Some theoretical foundation can be found for the form of the empirical relationships if it is assumed that the wind acts on each wave component independently, and that the sheltering coefficient used by Jeffreys is proportional to the wave steepness. The results provide a basis for making reasonably accurate predictions of waves and swell from meteorological charts and forecasts. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

2236. Pressure in a liquid. M. G. Bhatawdekar. *Indian J. Phys.*, **26**, 54–5 (*Feb.*, 1952).

Knowing the potential energy of a liquid, an idea is gained of the intermolecular forces. The pressure within the liquid at different temperatures is calculated by an application of the virial theorem. The virial function is seen to be a function of the volume of the liquid at that temperature; hence an equation of state for the liquid is derived. A.

532.7

2237. A discussion on theory of liquids: Introductory remarks. N. F. Mott. *Proc. Roy. Soc. A*, **215**, 1–3 (*Nov.* 6, 1952).

A comparison is given between flow in liquids, creep in crystals and intercrystalline slip. A further comparison is made between latent heats of fusion, shear moduli and the energies to form vacancies. A.

532.7

2238. A discussion on theory of liquids: Theories of the liquid state. J. de Boer. *Proc. Roy. Soc. A*, **215**, 4–28 (*Nov.* 6, 1952).

A critical discussion is given of the various theories of the liquid state, which give an explanation of the liquid properties in terms of the intermolecular forces. The general properties of the equation of state of monatomic liquids and the melting and vapour-pressure curve are given using the principle of corresponding states with molecular units. These experimental data are compared with the theory of Lennard–Jones and Devonshire. The influence of a smaller co-ordination number is investigated, and the difficulties in explaining the additive constant in the vapour pressure curve is discussed. The generalizations of the theory of Lennard–Jones and Devonshire, discussed recently also by Rowlinson and Curtiss [Abstr. 1519 (1952)], are given in a somewhat simplified representation, showing that the decrease of the co-ordination number can be obtained as a straightforward result of the application of statistical mechanics to the "lattice model" of the liquid state. The transition of the solid to the liquid phase is discussed, starting with Lennard–Jones and Devonshire's theory of melting. It is shown that the disordered "liquid" state corresponds to a liquid with a co-ordination number 9 and that an explanation can be given of the melting-point formula of Simon. Finally, attempts are discussed to base a theory of liquids on a calculation of the molecular distribution function. A.

532.7

2239. A discussion on theory of liquids: Transport processes in liquids. R. Eisenschitz. *Proc. Roy. Soc. A*, **215**, 29–36 (*Nov.* 6, 1952).

The object of the modern theory is to find the average flow of mass, momentum or energy, as observed in diffusion, viscous flow or thermal conduction, by means of the probability distribution for the co-ordinates and momenta of a representative molecule or pair of molecules. Transmission of momentum or energy in liquids, as distinct from gases, is due to the action of intermolecular forces. The probability distribution is determined by a differential equation similar to the equation of Fokker and Planck. Frequently it is sufficient to find the probability distribution in space co-ordinates only, by solving the equation of Smoluchowski. These equations are known to apply to the Brownian movement of large particles suspended in a liquid. Their validity for the movement of molecules was established only recently by combining the principles of statistics and dynamics and invoking a hypothesis of molecular chaos. The friction constants entering as parameters into the differential equations can, in principle, be derived from intermolecular forces; in practice this involves considerable difficulties. Even in its present incomplete stage the theory yields quantitative results comparing reasonably well with experiment. In addition it provides criteria for assessing the significance of viscosity formulae as put forward by previous authors. A.

532.7

2240. A discussion on theory of liquids: Viscosity of liquids. E. N. da C. Andrade. *Proc. Roy. Soc. A*, **215**, 36–43 (*Nov.* 6, 1952).

The author puts forward his views on the theory of viscosity of metallic liquids and discusses a number of experimental observations in the light thereof. He also discusses his work on (i) the influence of an applied electric field on the viscosity of liquids and (ii) the viscous behaviour of supercooled polar liquids. T. C. Toye

532.7

2241. A discussion on theory of liquids: Supercooling of liquids. F. C. Frank. *Proc. Roy. Soc. A*, **215**, 43–6 (*Nov.* 6, 1952).

A short review of the theory of supercooling, the work of Turnbull [Abstr. 4048 (1950)] is particularly referred to. T. C. Toye

532.7

2242. A discussion on theory of liquids: Discontinuities in the physical properties of supercooled liquids. N. N. Greenwood and R. L. Martin. *Proc. Roy. Soc. A*, **215**, 46–65 (*Nov.* 6, 1952).

The viscosity, electrical conductivity and density of several liquids have been measured over a range of temperatures both above and below the melting-point. The results confirm that the activation energy of viscous flow is greater in the supercooled state than in the normal liquid, the slope of the $\log \eta$, $1/T$ graphs increasing by about 10% on passing into the supercooled region. In the series of liquids formed by co-ordinating boron trifluoride to acetic acid and its methyl, ethyl, *n*-propyl and *n*-butyl esters the effect increases with the chain length of the alkyl radical. A similar discontinuity in the $\log \kappa$, $1/T$ curves indicates that the activation energy for ionic migration is also greater in the supercooled than in the normal state. Although this discontinuity in electrical conductivity has not been noted previously, it is shown to be implied in the numerical results of earlier authors. In contradistinction to viscosity and electrical conductivity, the density varies linearly with temperature over the whole range. These results are discussed in relation to the published data on the other physical properties of supercooled liquids. A.

532.7

2243. A discussion on theory of liquids: The spontaneous nucleation of supercooled water. B. J. Mason. *Proc. Roy. Soc. A*, **215**, 65–6 (*Nov.* 6, 1952).

The theoretical prediction that, in the vicinity of −40°C, the nucleation rate should increase very rapidly with falling temperature has been proved experimentally by the author. Observations were made of the rate of spontaneous crystallization of small droplets of supercooled water suspended in air.

T. C. TOYE

532.7

2244. Classical statistics in the consideration of the space requirements of particles. H. Falkenhagen and G. Kelbg. *Ann. Phys.* [*Leipzig*] **11**, *No.* 1, 60–4 (1952) *In German.*

An application of Eigen and Wicke's theory [see Abstr. 3967 (1952)]. T. C. TOYE

532.7

2245. Solutions of sodium in liquid ammonia. W. N. Lipscomb. *J. chem. Phys.*, **21**, 52–4 (*Jan.*, 1953).

Modifications of Ogg's treatment of the electron in a spherical cavity in liquid ammonia lead to a radius of about 4·8Å or slightly less, in reasonable agreement with the corrected experimental value of 3·2Å. Some specific quantum-mechanical interactions appear to be necessary in order to make the electron stable. A.

532.712

2246. Determination of osmotic coefficients. I. Construction and calibration of the thermistor bridge. C. G. McGee and B. R. Y. Iyengar. *Indian J. Phys.*, **26**, 61–6 (*Feb.*, 1952).

The apparatus and technique for measuring small vapour pressure differences of solutions are described. The method is based on the fact that the equilibrium temperature difference developed between a drop of solution and a drop of solvent, or reference solution, in an atmosphere saturated with solvent vapour is directly proportional to vapour pressure lowering. From this, osmotic coefficients are calculable. The advantages and the limitations of the method are discussed. A.

532.72

2247. Experiments on thermodiffusion in the liquid phase. Thermodiffusion in heavy water. I. Prigogine, L. de Brouckère and R. Buess. *Physica*, **18**, 915–20 (*Nov.*, 1952) *In French.*

Experiments on thermodiffusion of mixtures of heavy water are described. The Soret coefficient D'/D is found to be independent of composition. Its value $(7 \cdot 10^{-5} \pm 3 \cdot 10^{-5}\ \text{temp}^{-1})$ is discussed in connection with the kinetic theory developed in a previous paper of this series [Abstr. 3385 (1951)]. A.

532.72

2248. The effect of pressure on self-diffusion in carbon disulfide. R. C. Koeller and H. G. Drickamer. *J. chem. Phys.*, **21**, 267–73 (*Feb.*, 1953).

A method has been developed for measuring diffusion coefficients in liquids to 10 000 atm. pressure. Measurements have been made over this pressure range at 0°, 20° and 40°c for the system $CS_2 - CSS^{35}$. The results are interpreted in terms of the enthalpy, entropy and volume of activation as a function of temperature and pressure. A.

532.72 : 539.172.13

The proton-proton reaction and energy production in the sun. *See Abstr.* 2691

532.73 533.27 539.215.7

2249. The definition and measurement of some characteristics of mixtures. P. V. Danckwerts. *Appl. sci. Res A*, **3**, *No.* 4, 279–96 (1952).

The systematic study of mixing processes requires a quantitative method of expressing "goodness of mixing," based on conveniently-made measurements. In this paper, mixtures of mutually soluble liquids, fine powders, or gases are considered. It is shown that the important features of such mixtures can be expressed by two statistically-defined quantities; the scale and the intensity of segregation, and methods of measuring these are suggested. The discussion also throws light on some of the factors which affect the efficiency of mixing processes. A.

532.74 : 539.26 : 539.185

The structures of liquid tin, bismuth and lead. *See Abstr.* 2747, 2757

532.77

2250. On the theory of Maxwell's effect: effect of fluctuations of molecular form. Application to the determination of the structure of nucleic acids in solution. R. Cerf. *C.R. Acad. Sci.* [*Paris*] **235**, 1394–6 (*Dec.* 1, 1952) *In French.*

An earlier theory [Abstr. 1524 (1952)] considering the molecule as an elastic sphere, is applied to calculate Maxwell's effect for the general case where the fluctuations of the form of the molecules is not ignored.

T. C. TOYE

MECHANICS OF GASES 533

533.15 : 539.155.2

2251. Thermal diffusion in isotopic mixtures in the critical region. F. E. CASKEY AND H. G. DRICKAMER. *J. chem. Phys.*, **21**, 153–6 (*Jan.*, 1953).

Thermal diffusion ratios have been measured for the system $C^{14}O_2-CO_2$ temperature range $-15°C$ to $+50°C$ and to 160-atm. pressure. One isotherm at $-15°C$ has also been measured for the system $CH_4 - CH_3H^3$. The results deviate completely from the predictions of the kinetic theory of Enskog and Chapman and correspond closely to the previous results for the xenon-ethane system. The thermodynamics of irreversible processes qualitatively predicts the results obtained. A.

533.15 : 539.169

Tracer diffusion in the ground in radioactive leak location. *See Abstr.* 2682.

533.15.096

2252. On Drickamer's modification of the theory of the thermal diffusion column. K. HIROTA AND Y. KOBAYASHI. *J. chem. Phys.*, **21**, 246–9 (*Feb.*, 1953).

By use of thermal diffusion columns, the $N_2 - H_2$ system has been separated continuously and its thermal diffusion ratio α has been determined with a method of least ambiguity under a pressure range of $1 \sim 12{\cdot}6$ atm. The α-values thus obtained, based on the Furry–Jones theory of the apparatus, have been found to be not constant and also to differ very much in most cases from those hitherto reported. However, the values corrected according to the theory modified by Drickamer *et al.* [Abstr. 7783 (1950)] have been shown to be reasonable, supporting their modified theory. A.

533.27 539.215.7 532.73

The definition and measurement of some characteristics of measurements. *See Abstr.* 2249

533.5

2253. A flow-meter in vacuum technique. R. UYEDA AND Y. SUGIURA. *J. Phys. Soc. Japan*, **8**, 99–103 (*Jan.–Feb.*, 1953).

A direct reading flowmeter for the measurement of Q-value is described. The principle is the measurement of the force exerted on a disk placed in a vacuum piping. The kinetic theory shows that the force acting upon the suspending plate, due to the thermal motion of molecules, is stronger than one supposes and this is proved by the experiments. Flowmeters of suspension type are made and tested. The highest sensitivity available is 1×10^{-3} μHg litre/sec per 1 mm of scale. The application of this meter to measurement of pumping speed, measurement of desorbed gases, vacuum drying and leak detection are described. A.

533.6.013.22

2254. Experimental study of the spectrum of isotropic turbulence. III. H. SATO. *J. Phys. Soc. Japan*, **8**, 82–7 (*Jan.–Feb*, 1953).

For Pt II, see Abstr. 7108 (1952). In order to clarify the detailed structure of turbulence, measurements were made on the fluctuation of the spectral component from a band-pass filter. Using a voltage integrator and a counterchronograph, two quantities were observed in the so-called isotropic turbulence produced by a grid in a wind-tunnel. One is the distribution function of amplitude averaged in a certain time interval. Dispersions of distribution under various experimental conditions are computed and compared. The other is the time correlation function of fluctuating output. The magnitude of correlation is not so small even for a time interval of 0·5 sec and curves seem to be classified into two groups according to the central frequency. A.

MOLECULAR THEORY OF GASES 533.7

533.7

2255. On the ground state of a model for compressed helium. C. A. TEN SELDAM AND S. R. DE GROOT. *Physica*, **18**, 891–904 (*Nov.*, 1952).

In the problem of the "compressed helium atom," the boundary condition that the wave function ψ must vanish at infinity ($r = \infty$), is replaced by: $\psi = 0$ at a finite $r = r_0$. This problem is solved by a variational method, which for the limiting case of the free atom ($r_0 \to \infty$) coincides with one of Hylleraas' approaches to the helium problem. The energy and kinetic energy of the electrons in the ground state are calculated as functions of r_0 and the corresponding pressure. A.

533.7

2256. On the polarizability of a model of the compressed helium atom. C. A. TEN SELDAM AND S. R. DE GROOT. *Physica*, **18**, 905–9 (*Nov.*, 1952).

The helium atom, enclosed in a spherical box of radius r_0, has been used as a model of compressed helium. From wave functions for this model, the polarizability is calculated as a function of r_0 and the corresponding pressure. It is found that at 1000 atmospheres the polarizability is diminished by about $5\frac{1}{2}\%$. A.

533.7

2257. A calculation of internal kinetic energy and polarizability of compressed argon from the statistical atom model. C. A. TEN SELDAM AND S. R. DE GROOT. *Physica*, **18**, 910–14 (*Nov.*, 1952).

From Jensen's and Gombás' modification of the statistical Thomas–Fermi atom model, a theory for compressed atoms is developed by changing the boundary conditions. Internal kinetic energy and polarizability of argon are calculated as functions of pressure. At 1000 atm. an internal kinetic energy of about 5·2 kcal/mole is found; the polarizability is about 2·9% less than that at zero pressure. The change with pressure of these quantities is in rough agreement with experimental results at high densities. A.

533.7

2258. The second virial coefficient near absolute zero. H. S. GREEN. *Proc. Phys. Soc.* [*London*] *A*, **65**, 1022–9 (*Dec.*, 1952).

By the solution of Bloch's equation for the density matrix, a development is obtained suitable for the

exact evaluation of the second virial coefficient near absolute zero. Assuming a molecular interaction of the Lennard–Jones type, it is shown that the virial coefficient for helium is $-\{\frac{1}{2}(\pi\beta)^{3/2} + 31{\cdot}15\pi\beta + O(1)\}$Å^3, $\pi\beta = 38{\cdot}04/T$. General formulae are given for fluids the molecules of which satisfy Bose or Fermi statistics. A.

533.7

2259. The representation of gas properties in terms of molecular clusters. H. W. Woolley. *J. chem. Phys.*, **21**, 236–41 (*Feb.*, 1953).

The equation of state of a gas in virial form is derived from the equilibrium constants for the formation of molecular clusters. It is indicated that by choosing effective Lennard–Jones parameters independently for clusters of various numbers of molecules, the actual virial coefficients may be represented more satisfactorily. Results for the third virial coefficient are shown for A, N_2, CO, CO_2, CH_4, C_2H_4, CF_4 and Xe. A.

533.7

2260. A quantum-mechanical treatment of virial-coefficients. J. E. Kilpatrick. *J. chem. Phys.*, **21**, 274–8 (*Feb.*, 1953).

The virial equation of state for gases has been developed with the quantum-mechanical grand partition function as a basis, instead of with the usual Slater sum or the density matrix. Attention is thereby focused on the energy levels of systems of one, two, three, etc., molecules rather than on their wave functions. An explicit, closed solution has been found for the nth virial coefficient in terms of the first n cluster integrals which is valid either classically or quantum mechanically. A simple generating function for the virial coefficients has been proposed. A.

VIBRATIONS . ACOUSTICS 534

534.121.1 : 537.228.1 : 621.396.611.21

Vibrations of piezoelectric plates. *See Abstr.* 2439–40

534.15 : 539.67

Apparatus for measuring internal friction in transversely vibrating reeds. *See Abstr.* 2775

534.21

2261. The disturbance due to a line source in a semi-infinite elastic medium with a single surface layer. M. Newlands. *Phil. Trans A*, **245**, 213–308 (*Dec.* 16, 1952).

An investigation is made of the disturbance created by a cylindrical pulse (of *P*- and *S*-type) emitted from a line source in a surface layer of elastic material overlying a semi-infinite medium of different elastic constants and density. An exact formal description of the motion is obtained in terms of a succession of pulses; the double integrals corresponding to each are evaluated by approximate methods. It is found that at a remote point (at or near the surface) there should be felt pulses corresponding to travel by each one of the minimum-time-paths predicted by the ray theory, and, in addition, a whole series of diffraction effects. Ray-path pulses are of the same type as the initial pulse, showing the same "jerk" in the displacements (or in the rate-of-change of these); diffraction pulses are in general "blunt," but certain of them become sharper as the surface is approached until, at the surface, they become part of a minimum-time-path disturbance. The apparent *S*- and *Sg*-anomalies are considered in the light of these results. At a certain range interference between pulses becomes important, and at very great range the dispersive Rayleigh wave-train becomes the dominant feature. A further study of the propagation of free Rayleigh waves shows that an infinite number of modes of vibration are possible. The degree to which each is excited and the resultant motion is determined; the importance of the Airy phases is demonstrated. The pulse representation has a natural extension to systems of any number of layers; before the corresponding interference pattern at great range can be determined it will be essential to extend our knowledge of the dispersion of free surface waves to such multilayered systems. A.

534.21

2262. Nonlinear dissipative distortion of progressive sound waves at moderate amplitudes. J. S. Mendousse. *J. Acoust. Soc. Amer.*, **25**, 51–4 (*Jan.*, 1953).

The first part deals with the case of a simple-harmonic wave which becomes eventually distorted into a relatively stable shape resembling the shape of a saw-tooth wave with rounded-off corners. A simplified-picture theory is developed in which the wave is idealized as consisting of a nondissipative linear portion of length λ_1 and a dissipative simple-harmonic portion of length λ_2. The amplitude A of the distorted wave and its rate of absorption α_A are computed (1) from the dissipative wavelength $2\lambda_2$ and (2) from the "build-up distance" $L = N\lambda$ at which stability of shape is achieved, both λ_2 and N being regarded as experimental data. Tests of the theory are made by using shadowgrams of waves generated in air by a piezoelectric quartz at the frequency of 0·405 Mc/s. The second part presents an approximation treatment of the classical wave equation in which either of two different transformations of variables lead to a quasi-linear differential equation of the type $\partial^2 z/\partial y^2 = \partial z/\partial x + \partial(z^2)/\partial y$. In the first transformation, more suitable for periodic waves, x is used for the distance from the source and y for the time, while the reverse is done in the second transformation, more suitable for shock waves. An exact solution is given for the case of the simple-harmonic source already discussed in the first part. A.

534.22/.23 : 541.64

2263. Ultrasonic-wave study of swollen Buna-N rubber. A. W. Nolle and J. F. Mifsud. *J. appl. Phys.*, **24**, 5–14 (*Jan.*, 1953).

The velocity and attenuation of ultrasonic waves are measured as a function of temperature in specimens of a Buna-N vulcanizate swollen to various degrees with methyl ethyl ketone. The frequencies are 2, 5 and 10 Mc/s. The experimental method consists of determining the insertion loss and the time delay due to insertion of a flat sample in the liquid acoustic medium of a pulse-reflection apparatus; an improved technique of observation, in which

phase delay as well as envelope delay is examined, leads to more precise time data than previous applications of the method. As solvent content of the specimen increases, the position of the maximum of attenuation with respect to temperature moves to lower temperatures, and the height of the attenuation peak is reduced. It is shown that the height of the attenuation peak, when corrections are made for temperature effects according to the mechanisms of rubberlike elasticity, is proportional to the mass of polymer per unit volume in the swollen specimen; moreover, the temperature of maximum attenuation is a linear function of the ratio, for the swollen specimen, of mass of solvent to mass of polymer. The latter finding indicates, if the concept of energy of activation is applicable, that the reduction of activation energy is proportional to the number of solvent molecules associated with each polymeric "chain segment." The paper contains auxiliary data on dimensional and volumetric aspects of swelling and swelling rate. A.

534.22 : 541.182.6

2264. On the ultrasonic velocity in suspension. T. Soeya. *J. Fac. Sci. Hokkaidô Univ., II*, **4**, 90–4 (*Feb.*, 1951).

The ultrasonic velocity in suspension and its relation to temperature were measured for various specimens. Experimental results only are described. A.

534.222.2

2265. The diffraction of strong shock waves. W. Griffith and D. E. Brickl. *Phys. Rev.*, **89**, 451–3 (*Jan.* 15, 1953).

The pseudostationary flow field resulting from diffraction of a strong shock in air over a convex corner has been investigated with the shock tube and interferometer. Only when the shock has turned nearly 180°, is it observed to become vanishingly weak. A potential flow theory for part of the field is inadequate to predict the extent of a Prandtl–Meyer expansion around the corner. Viscous forces produce a boundary layer which causes the flow to separate at the corner with significant changes in the density field as a result. A.

534.23 : 532.527

2266. The theory of steady rotational flow generated by a sound field. P. J. Westervelt. *J. Acoust. Soc. Amer.*, **25**, 60–7 (*Jan.*, 1953).

Starting from the Navier–Stokes equations, a general equation governing the generation of vorticity $\mathbf{R}$ is obtained: $\nabla^2\mathbf{R} = \mu_0^{-1}\nabla\times\nabla\cdot\langle\rho_0\mathbf{uu}\rangle$, wherein $\mathbf{R}$ is the time-independent vorticity in the Eulerian frame and $\langle\rho_0\mathbf{uu}\rangle$ is the average value of Reynolds' stress dyadic. The solution to this vorticity equation, when properly transformed to the particle coordinates, is shown to be divergence free. A specialization of the vorticity equation to the case of solenoidal first-order motion is shown to lead to the generating term employed by Rayleigh and by Schlichting; a specialization to the case of irrotational first-order motion is shown to lead to the generating term employed by Eckart. The sum of the two specialized driving terms does not equal the general term, indicating that the contributions to vorticity from rotational and compression effects are not independent of one another. The theory is applied to find the streaming generated by a well defined beam of sound giving results agreeing with Eckart and with Markham. However, when it is applied to a two-dimensional standing wave problem, the configuration of the streaming velocity in the boundary layer is found to differ from the results obtained by Rayleigh. Finally, the effect on streaming of a time-dependent viscosity coefficient is examined. A.

534.23 : 541.14

2267. The emission of ultra violet from water under the action of ultrasonics. R.-O. Prudhomme and R.-H. Busso. *C.R. Acad. Sci.* [*Paris*] **235**, 1486–8 (*Dec.* 10, 1952) *In French.*

Experimental verification. T. C. TOYE

534.23

2268. Ultrasonic absorption in mixtures of ethyl alcohol and water. L. R. O. Storey. *Proc. Phys. Soc.* [*London*] *B*, **65**, 943–50 (*Dec.*, 1952).

The pulse method has been used to measure the absorption of ultrasonic waves in mixtures of ethyl alcohol and water at the three frequencies 22·5, 37·5 and 52·5 Mc/s and at the temperatures 0°, 10° and 25°c. The results confirm the findings of earlier workers that in both the pure liquid and the mixture there is more absorption than can be explained by the classical mechanisms of viscosity and heat conduction. When the composition of the mixture is varied a maximum of absorption is found for a mixture containing 20 to 30 molar per cent alcohol. The magnitude of the absorption at the maximum increases rapidly as the temperature is lowered. Over a range of compositions in the neighbourhood of the maximum the value of α/f^2 (α is the absorption coefficient and f the frequency) is found to decrease as f increases. It is known that the extra absorption in the pure liquids can be explained in terms of a compressibility with a finite relaxation time, but this mechanism alone cannot account for the behaviour of the mixture. It is suggested that here the additional absorption is due to interaction between the molecules of the two components, leading to the partial development of a structure or complex in the liquid with a composition of four molecules of water to one of alcohol. The thermal properties of the mixture indicate that such interaction occurs, and the suggestion for the composition of the complex is supported by the fact that the freezing-point curve for the mixture shows that a structure with this composition is formed in the solid phase. The extra absorption found by other workers in several similar mixtures can be explained, at least qualitatively, in the same way. A.

534.23

2269. Determination of ultrasonic absorption in liquids at 5 Mc/s from thermal considerations. S. Parthasarathy, D. Srinivasan and S. S. Chari. Note in *Naturwissenschaften*, **39**, *No.* 23, 544–5 (1952).

In previous work at 420 kc/s [Abstr. 1675 (1951)] a correlation was established for a number of liquids between the heat output h and the classical value of

α/ν^2, where α = absorption coefficient and ν = frequency. Assuming a constant (empirical) value now for the ratio $h/(\alpha/\nu^2)$, α/ν^2 is determined for a number of liquids at 5 Mc/s, good agreement with values from radiation pressure measurements being obtained. For anomalous absorbing liquids $h/(\alpha/\nu^2)$ is not constant at 5 Mc/s however. T. C. TOYE

534.23

2270. The effects of viscous dissipation in the spherical acoustic resonator. H. G. FERRIS. *J. Acoust. Soc. Amer.*, **25**, 47–51 (*Jan.*, 1953).

The problem of the spherical acoustic resonator containing a slightly viscous medium is considered. Derivation of the equations of sound waves in a viscous medium is carried out, and it is shown that separation of the particle velocity into a divergenceless vector and a curl-less vector gives rise to both a vector Helmholtz equation and a scalar Helmholtz equation. By using known solutions to these equations in spherical coordinates and imposing suitable boundary conditions, the frequencies of the free vibrations are calculated as well as the attenuation constants associated with each frequency. The effect of viscosity is, thus, seen to decrease slightly the natural frequencies and to cause a time rate of decay of the free vibrations. The attenuation constant for the purely radial modes of vibration is much smaller than that for modes having tangential velocity components. A.

534.23

2271. Acoustic streaming due to attenuated plane waves. W. L. NYBORG. *J. Acoust. Soc. Amer.*, **25**, 68–75 (*Jan.*, 1953).

Theories for calculating steady streaming associated with sound fields are reviewed, comparing the methods and approximations of various authors. Two illustrative problems are worked out, both for rectilinear flow due to irrotational sound fields. The first deals with a single attenuated plane wave travelling down a tube, as in Cady's quartz wind experiments. In the second, a pair of crossed plane waves is treated, giving rise to a quite different kind of streaming. In obtaining solutions, attention is given to boundary conditions; here, gradients of the excess static pressure, another second-order quantity, come into consideration. Significantly, streaming speeds depend critically upon α, the attenuation constant, where α may be due to any common cause, such as heat conduction, scattering, thermal relaxation, etc. From these results it appears that streaming measurements cannot be used to distinguish between absorption mechanisms. Numerical values are given for a few cases; high flow speeds may be expected in a bubbly medium. A.

534.23 : 539.32

2272. Some acoustical properties of lead and other substances at liquid nitrogen temperature. P. J. ERNST AND P. ZAYON. Letter in *J. Acoust. Soc. Amer.*, **25**, 152–3 (*Jan.*, 1953).

Simple experiments are described by which some acoustic and elastic properties of Pb, Cu and Al at liquid N temperature (−195°c) are partly substantiated and partly disproved. Further investigations by ultrasonic methods are in progress to find a theoretical explanation for the remarkable behaviour of these metals. A. B. WOOD

534.23 : 578.088.2

2273. Action of ultrasound on nerve tissue—a review. W. J. FRY. *J. Acoust. Soc. Amer.*, **25**, 1–5 (*Jan.*, 1953).

Concerned with (1) certain physiological and structural changes produced in tissues of the central nervous system caused by high level ultrasound and (2) investigations into the physical mechanisms underlying these changes. The cell bodies of neurons in the central nervous system are particularly susceptible to change by ultrasound. The effect of irradiation is immediately evident as a loss of function which may be reversible or irreversible depending on the dosage. Irreversible changes in function are accompanied by changes in the structure of the cell. The susceptibility of neurons studied so far is graded according to size, the larger neurons exhibiting a greater susceptibility. The dose of ultrasound can be adjusted to cause irreversible changes in neurons without causing any observable damage to the vascular and supporting components of the tissue. This selective and specific effect of ultrasound is being used as a tool in neuro-anatomical studies now in progress and has considerable potential value in neurosurgery. The ultrasound alters the state of the nerve cells and, therefore, affords a basis for studying intracellular structure and function. The physical basis for the ultrasonically produced biological effects has been investigated in part. The following aspects of temperature have been analysed and rejected: (1) high average (space) level; (2) interface heating; (3) rapid time rate of change; (4) temperature changes resulting from cavitation; (5) heating at gas nuclei. The phenomenon of cavitation is also shown to play no essential direct role in producing the effects. A.

534.23 : 578.088.2

2274. Temperature changes produced in tissue during ultrasonic irradiation. W. J. FRY AND R. B. FRY. *J. Acoust. Soc. Amer.*, **25**, 6–11 (*Jan.*, 1953).

Concerned with the technique of temperature measurement in living tissue during irradiation by high intensity ultrasound. The interpretation of data obtained by the use of thermocouples is presented. The specific biological object used in this study is the spinal cord of rat exposed by laminectomy. This particular preparation serves to illustrate the relative importance of the heat conduction process in contributing to the temperature change as a function of the proximity of the imbedded thermocouple to bone and the time elapsed after initiation of the exposure. The ultrasonic frequency used in these studies was 980 kc/s. The sound intensities incident on the cord were between 60 and 80 watts/cm^2. The experimental results presented are used to obtain values for the acoustic absorption coefficient of the tissue of the spinal cord. The range of values obtained for the intensity absorption coefficient per cm from measurements made on six adult rats at various positions in the spinal cord is 0·19 to 0·23 if the heat capacity of the tissue at constant pressure is 1·00 calorie/cm^3. A.

534.23 : 578.088.2

2275. Temperatures produced in tissues by ultrasound: experimental study using various technics. J. F. HERRICK. *J. Acoust. Soc. Amer.*, **25**, 12–16 (*Jan.*, 1953).

Experiments have been carried out to investigate ultrasound as a possible therapeutic agent. These show that selective heating occurs in nerves and bones treated *in situ*. Effects of direct heat on nerves are strikingly similar to the effects of ultrasound. Blocking of nerves by sound or heat with present techniques seems impractical because the margin of safety is too narrow. A.

534.23 : 578.088.2

2276. The biophysical mode of action of biologic and therapeutic ultrasonic reactions. J. F. LEHMANN. *J. Acoust. Soc. Amer.*, **25**, 17–26 (*Jan.*, 1953).

A review is presented of numerous biophysical studies concerning the action of ultrasound on living matter with particular reference to therapeutic applications. On the basis of the experiments described, involving various physical, physiochemical, and chemical effects, it is concluded that selective heating caused by the radiation plays the major role quantitatively under therapeutic conditions. However, ultrasound also produces a mechanical effect. The diffusion layer at an interface is decreased by stirring and thus exchange of metabolites is augmented. A.

534.231.3

2277. Periodic fluid flow through circular orifices. G. B. THURSTON AND C. E. MARTIN, JR. *J. Acoust. Soc. Amer.*, **25**, 26–32 (*Jan.*, 1953).

The results of an experimental investigation of both the linear and nonlinear acoustic impedance of circular orifices with water and 10-centistoke Dow Corning silicone fluid are presented. Experimental determinations of the end corrections for acoustic resistance and acoustic inductance are in good agreement with the classical end correction as given by Rayleigh for acoustic inductance. A series of determinations of the criteria for the onset of nonlinearity in acoustic resistance and acoustic inductance together with photographs of the fluid flow patterns developed are presented. A characteristic of one of the fluid flow patterns is correlated with the onset of nonlinearity. A.

534.231.3

2278. Small-signal impedance of short tubes. A. W. NOLLE. *J. Acoust. Soc. Amer.*, **25**, 32–9 (*Jan.*, 1953).

Relations expressing the acoustic inertance and resistance of short open tubes in terms of $k_v a$ are reviewed. The tube radius is a; k_v is the complex wave number for viscosity waves. Analogous relations giving the acoustical impedance of a cylindrical cavity in terms of $k_T a$, where k_T is the thermal wave number, are considered. Viscous and thermal losses have sometimes been incorrectly separated in the literature. Past measurements, showing disagreement between theory and experiment for small $k_v a$, are cited. New measurements of inertance and associated resistance, in the range of $|k_v a|$ from 1 to 77, are reported. The method of standing wave analysis is used. In some instances the inertance tube is incorporated in an adjustable-cavity resonator. Inertance values after end corrections agree with theory within 2·5%. Corrected resistance values generally agree with theory within 3% for $|k_v a| < 10$. Greater discrepancies for larger values of $k_v a$ are attributed to excessive losses in very short cavities. Consideration of present results together with published data for larger values of $k_v a$ indicates close agreement of theory and experiment for a range of $k_v a$ extending at least from unity to several hundred. A.

534.231.3

2279. The physical interpretation of the expression for an outgoing wave in cylindrical coordinates. M. C. JUNGER. *J. Acoust. Soc. Amer.*, **25**, 40–7 (*Jan.*, 1953).

The sound field generated by a vibrating cylinder of infinite length, whose dynamic configuration is periodic in ϕ and z, is expressed in terms of acoustic impedance ratios. It is noted that symmetrical modes of vibration are suppressed at certain frequencies because the corresponding reactive impedance is infinite, and that all z dependent modes become nonradiating below certain "cut-off" frequencies, the corresponding impedance being purely reactive. Graphs are presented for the impedance ratios corresponding to certain modes. For modes independent of z, the sound field is in the form of concentric cylindrical waves. For z dependent modes, as the plane wave wavelength increases from zero to a certain critical cut-off value, the sound field changes from a set of concentric cylindrical waves to two sets of conical waves of decreasing vertex angle; at and beyond the cut-off point, the conical waves have degenerated into a set of plane standing waves normal to the z axis. Simultaneously, the sound field has ceased being periodic in the radial direction, and the phase velocity in that direction has become infinite. Practical applications of these phenomena are suggested. A.

534.232

2280. Effect of a finite circular baffle board on acoustic radiation. T. NIMURA AND Y. WATANABE. *J. Acoust. Soc. Amer.*, **25**, 76–80 (*Jan.*, 1953).

The effect of a finite circular baffle board on acoustic radiation was computed by the use of the oblate spheroidal wave function developed by Kotani and by Boukamp. The directivity, power radiation, and radiation impedance of the vibrating disk with a concentric circular baffle board are shown together with a design diagram for a circular baffle board. A.

534.232

2281. Characteristics of jet-edge-resonator whistles. W. L. NYBORG, C. L. WOODBRIDGE AND H. K. SCHILLING. *J. Acoust. Soc. Amer.*, **25**, 138–46 (*Jan.*, 1953).

A jet-edge-resonator (JER) whistle consists essentially of a jet-edge (JE) system, such as may itself produce edge tones, and a resonator. Sound fields generated by such sources are described, as well as dependence of various aspects of these fields on airflow and whistle dimensions. Empirical findings are interpreted in terms of independently determined properties of JE systems and of resonators. A method

is described for adjustment of a given whistle to maximum or near-maximum output for a given frequency. Typical output data so obtained are presented for each of several models. Approximate values are also given of the modulation coefficient M for various circumstances. This quantity is an index of effectiveness with which steady flow into a whistle is converted into a sinusoidally varying flow out of its mouth. A.

534.232

2282. Auxiliary mechanical sound sources for obstacle perception by audition. V. TWERSKY. Letter in *J. Acoust. Soc. Amer.*, **25**, 156–7 (*Jan.*, 1953).

A description is given of two types of high frequency sound source for echo detection of objects in air. In both types a small ($3\frac{1}{2}$ in. dia.) parabolic reflector is used, the source in the first case being a small steel reed plucked by a trigger mounted at the apex of the reflector and in the second the source is a small high pitched (8 to 16 kc/s) whistle operated by hand pressure on a small rubber bulb mounted on the wall of the reflector. Tests were made using blindfolded subjects in the open, using the side of a car as the obstacle. The maximum range was not stated, but minimum ranges varied for 10 to 20 ft. Pitch and loudness increases were observed on approaching the reflecting obstacle. The whistle unit was preferred. A. B. WOOD

534.26

2283. Scattering of cylindrical waves by a cylinder. J. J. FARAN, JR. Letter in *J. Acoust. Soc. Amer.*, **25**, 155–6 (*Jan.*, 1953).

A few scattering patterns illustrative of the effects of curvature of the incident wave fronts have been computed. The general similarity between the cylindrical and spherical cases of plane-wave scattering indicates that much the same behaviour will be observed in considering the scattering of spherical waves by a sphere. Curves are reproduced illustrating the relative amplitude of pressure in the wave scattered by a rigid immovable cylindrical scatterer. A. B. WOOD

534.3

2284. Acoustical properties of trumpets. J. IGARASHI AND M. KOYASU. *J. Acoust. Soc. Amer.*, **25**, 122–8 (*Jan.*, 1953).

Acoustical properties of the B♭ trumpet were investigated. By comparing two trumpets judged to have good and poor musical quality, respectively, it was found that the air leakage at the pistons reduced the Q value of the resonance. An irregular frequency distribution of the higher normal modes of the trumpet was also studied. The effect of the connecting condition of the tube and horn of the trumpet on the harmonic relation of the normal modes of the air column was studied. The measured resonance frequencies were found to agree well with the maximum driving point radiation resistance computed for various combinations of tube and horn. A.

534.321.4

2285. Frequencies resulting from distortion. C. WILLIAMSON. Letter in *Amer. J. Phys.*, **21**, 68 (*Jan.*, 1953).

A comment upon Abstr. 5629 (1952) concerning the origin of the additional frequencies found by Fourier analysis of a distorted wave train. These are not due to resonances in the distorting device. A comparison is made with amplitude modulated radio transmission. R. W. FISH

534.321.9 : 535.42

The propagation of narrow light beams in liquids traversed by ultrasound. *See Abstr.* 2388

534.321.9 : 535.822.9

2286. The application of the phase method in visualizing ultrasonic waves. Y. TORIKAI AND K. NEGISHI. *J. Phys. Soc. Japan*, **8**, 119–24 (*Jan.–Feb.*, 1953).

In the usual schlieren method for visualizing ultrasonic waves, the zeroth order diffraction image is perfectly screened, while in the present method the image receives a proper absorption and phase retardation by the phase plate placed in the diffraction plane. According to the theoretical calculations, the phase retardation for the maximum visibility of the image of progressive waves with the stroboscopic illumination is $\pi/2$ and the optimum absorption varies with the intensity of the waves. In both cases of the usual method and the present phase method, the theoretical curves are compared with the experimental results, showing quite good agreement. Further, fine structures in the images are seen with increase of sound intensity. A.

534.39

2287. Radiation pressure and dispersion. E. J. POST. *J. Acoust. Soc. Amer.*, **25**, 55–60 (*Jan.*, 1953).

Starts with a brief discussion of the two components of acoustical radiation pressure in contrast with the single component obtained for electromagnetic radiation in vacuum. The two components of acoustical radiation pressure are correlated in a simple manner with the two distinct interaction possibilities of the obstacle and the medium; i.e. interaction with the wave motion only or interaction with the wave motion as well as with the medium itself. This picture appears to be consistent with the earlier conclusions of Brillouin and Richter. Afterwards the result is generalized for dispersive media. It is shown that the component which is usually stated to be independent of the equation of state in the existing non-dispersive theories should contain the time parameters of the equation of state in the form of a multiplying factor group, velocity over phase velocity. The present paper stresses the basic concepts rather than mathematical detail and concludes with an extensive bibliography and commentary. A.

534.42

2288. Thoughts on the imitation of natural sounds. D. W. MARTIN. Letter in *J. Acoust. Soc. Amer.*, **25**, 158–9 (*Jan.*, 1953).

A brief outline suggesting methods of imitating such sounds as (1) impulsive noises, (2) random noises, (3) simple musical tones, (4) steady-state musical tones, (5) percussive musical tones, (6) the human voice. The discussion deals with the principal characteristics of these sounds and the attempts which have been made to imitate them. A. B. WOOD

534.6

2289. Interferometric apparatus for ultrasonic detection. C. ROSSETTI. *C.R. Acad. Sci.* [*Paris*] **235,** 1484–6 (*Dec.* 10, 1952) *In French.*

Three arrangements are mentioned for detecting and measuring ultrasonic waves in a column of gas at freqs. of about 1 Mc/s. A quartz crystal transmitter is used in each case in conjunction with a reflector which may be either a metal plate, a crystal receiver or a second crystal oscillator. The reflector can be moved by a micrometer screw and the standing-wave pattern detected by periodic variations in either the transmitter current, receiver voltage or second oscillator voltage. G. F. HODSMAN

534.61

2290. Measurement of ultrasonic intensities in water. W. S. STUART. *Proc. Leeds Phil. Lit. Soc.*, **6,** *Pt* 1, 18–24 (1952)

An instrument has been designed for the measurement of ultrasonic intensities in water. It depends on the heating of a poor acoustic conductor (polystyrene or Perspex) by absorption of energy from the sound waves. The temperature is measured by means of a thermistor and a relation between resistance and ultrasonic intensity is given. T. C. TOYE

534.612

2291. The initial-throw method of operation of a Rayleigh disk. J. L. SIMONDS AND R. HELLER. Letter in *J. Acoust. Soc. Amer.*, **25,** 157–8 (*Jan.*, 1953).

A brief note describes an alternative to the customary operation of a Rayleigh disk, by which a considerable saving of time may be effected. Instead of measuring the steady angular deflection ϕ of the disk as caused by the sound field, observation is made of the initial throw ϕ_0 which results when the disk, originally at rest, is subjected to the sound field to be studied. A simple relation is obtained between ϕ and ϕ_0. A. B. WOOD

534.612.4

2292. The calibration and use of probe-tube microphones. R. W. BENSON. *J. Acoust. Soc. Amer.*, **25,** 128–34 (*Jan.*, 1953).

A study was undertaken to obtain the free-field and the coupler calibrations of several probe-tube microphones with tubes of different sizes and to determine those characteristics of a probe tube which are necessary for accurate measurements in both a free field and in closed couplers. For accurate measurements with a probe-tube microphone, precautionary measures must be taken. The probe tube must be sealed to the frame of the microphone in order to prevent an acoustic leak. Such a leak causes a reduction in the output of the probe-tube microphone at the lower frequencies. A probe tube with a high input impedance should be used for making measurements in a closed coupler. A high input impedance is necessary if the pressure in the coupler is to remain the same as before the insertion of the probe tube. If measurements are to be made with the accuracy of measurements made with a standard laboratory microphone, there is a significant difference between the pressure and the free-field calibrations of probe-tube microphones. A.

534.614

2293. Precision measurement of the velocity of sound in air. P. W. SMITH, JR. *J. Acoust. Soc. Amer.*, **25,** 81–6 (*Jan.*, 1953).

A method for the precise measurement of the velocity of sound is described in which the driving-point impedance of a loudspeaker connected to a closed tube of variable length is the frequency-controlling element of a bridge-stabilized oscillator. The operation of the system and the accuracy of measurement are analysed. Results of measurements in air at 1 kc/s, room temperature and atmospheric pressure yield, when corrected to standard conditions, a velocity of $331{\cdot}45 \pm 0{\cdot}05$ m/sec. A.

534.614 : 534.62 : 535.417

2294. An eleven megacycle interferometer for low pressure gases. M. GREENSPAN AND M. C. THOMPSON, JR. *J. Acoust. Soc. Amer.*, **25,** 92–6 (*Jan.*, 1953).

An automatic recording double-crystal interferometer is described which measures the speed and attenuation of sound at about 11 Mc/s in gases at pressures of a fraction of a mm Hg. A.

534.62

2295. Some design considerations for high frequency anechoic tanks. M. S. WEINSTEIN. *J. Acoust. Soc. Amer.*, **25,** 101–5 (*Jan.*, 1953).

By an extension of the techniques of Lindsay, the reflection from a semi-infinite attenuating medium is derived for the case of oblique angles of incidence. The results are applied to the design of a water tank each wall of which is assumed to be covered by a sheet of absorbing material. The optimum physical properties of the absorber required to make the tank anechoic in the megacycle region are then determined theoretically. Experimental measurements at 3·35 Mc/s indicate that the properties of tan *rho-c* rubber are very close to optimum. With a ¼-in. thick sheet backed by aluminium the reflection coefficient is about −30 db at normal incidence and rises to −20 db at an incident angle of 60°. Beyond 60° the rubber is of little value in reducing the reflectivity. The results obtained are in good agreement with those expected from the theoretical treatment when modified for reflections from the back surface and the phase difficulties previously described by the author. A.

534.62 : 612.85

Early work on the instrumental ear. *See Abstr.* 2866

534.62

2296. On the measurement of sound absorbing material in resonance chambers. B. D. TARTAKOVSKIĬ AND M. M. EFRUSSI. *Dokl. Akad. Nauk SSSR,* **82,** *No.* 3, 373–6 (1952) *In Russian.*

Experimental data is given on the variation of the measured absorption coefficient with the position of the absorbing material within the cavity. It is shown that differences as large as 45% may occur when measurements made "in an angle" and "on the surface" of a rectangular resonator. J. M. HOUGH

534.62 : 535.417

2297. A fixed path ultrasonic interferometer for absorption measurements on gases. J. F. W. BELL. *J. Acoust. Soc. Amer.*, **25,** 96–100 (*Jan.*, 1953).

A fixed path interferometer, using variable temperature for the measurement of the absorption in

gases in the low f/p region is described. Its use is illustrated by measurements on A, Ne, air, N and N–H mixtures at 250 kc/s. The values found for A and Ne were above classical by 40 and 65% respectively. The discrepancies are ascribed to Rayleigh cross modes in the ultrasonic waves excited by the quartz crystal transducer rather than to any departure from classical theory. Cross modes and their influence on ultrasonic measurements are discussed. Data on the performance of two crystals at 250 and 500 kc/s are given. A.

534.7 : 612.85

Physiological acoustics. Hearing. *See Abstr.* 2865–6

534.78

2298. The human voice in electrical models. F. WINCKEL. *Elektrotech. Z.* [*ETZ*] *A*, **73**, 708–11 (*Nov.* 11, 1952) *In German.*

The speech process is depicted first in terms of anatomical models, then of mechanical and electrical analogues, and it is shown how the complex waveforms may be interpreted by Fourier analysis or better by information theory. The most accurate picture is that of square-wave pulses generated in the larynx and modulated by the resonant cavities of the mouth and nose, and examples are given of spectra illustrating normal and defective voices. F. T. FARMER

534.78

2299. The influence of consonant environment upon the secondary acoustical characteristics of vowels. A. S. HOUSE AND G. FAIRBANKS. *J. Acoust. Soc. Amer.*, **25**, 105–13 (*Jan.*, 1953).

The consonant environments of vowels were varied by forming non-meaningful stimulus syllables consisting of 72 combinations of six vowels and 12 consonants. The syllables were spoken by subjects, and the duration, fundamental frequency and relative power of the vowels were measured. All three factors varied significantly in response to changes of the consonant environment. The variations were systematically related to the attributes of the consonants, the most powerful attribute being the presence or absence of vocal fold vibration, followed by manner of articulation and place of articulation, in that order. A.

534.78

2300. Auditory tests with synthetic vowels. R. L. MILLER. *J. Acoust. Soc. Amer.*, **25**, 114–21 (*Jan.*, 1953).

The results are given for a series of phonetic evaluation tests which were made by means of synthetically produced vowel sounds. By employing synthetically produced sounds, a number of the significant parameters could be varied in an independent and systematic manner without encountering the uncertainties and limitations of the human speech mechanism. The types of parameter changes which were investigated by this means were those of fundamental frequency or pitch, formant frequency and amplitude, and, finally, the number of formants important to a sound. The results of the tests indicate that all of these parameters are important in the evaluation of the sound. In particular, there is a shift in the phonetic evaluation which can be attributed to pitch alone. A.

534.83

2301. Unsolved military noise problems. L. L. BERANEK. *J. Acoust. Soc. Amer.*, **24**, 769–72 (*Nov.*, 1952).

After a brief summary of some of the more important noise problems left over from the war, the paper deals in more detail with the problem of reduction of aircraft noise. Diagrams are shown indicating the loudness levels beneath various types of modern passenger aircraft. These diagrams are shaded black (major nuisance), cross hatched (sizeable nuisance), slantshaded (moderate nuisance) and white (no nuisance). The major nuisance range extends from 2 to 16 miles, sizeable nuisance from 8 to 32 miles, and moderate nuisance from 20 to more than 40 miles—the range varying with the type of aircraft. The paper concludes with a brief discussion on the reduction of structure-borne noise, and on micrometeorological studies. A. B. WOOD

534.844.1

2302. The accuracy of reverberation time measurements with warble tones and white noise. W. FURRER AND A. LAUBER. *J. Acoust. Soc. Amer.*, **25**, 90–1 (*Jan.*, 1953).

It is shown that in reverberation time measurements warble tones give greater accuracy at the lower frequencies, and white noise at the middle and higher frequencies, this behaviour being within a wide range independent of room volume. A.

534.845.1

2303. Long-tube method for field determination of sound-absorption coefficients. E. JONES, S. EDELMAN AND A. LONDON. *J. Res. Nat. Bur. Stand.*, **49**, 17–20 (*July*, 1952).

A method has been developed that makes it possible to measure the sound-absorption coefficient of acoustic materials that have been installed. The method uses a portable version of the familiar impedance tube, in which measurements on the standing sound-wave pattern are used to obtain the sound-absorption coefficient for normally incident sound. The sound-absorption coefficient for randomly incident sound may be determined from the tube measurements by reference to an extensive table given in the paper. The tube is coupled to the acoustic material without defacing its surface so that the test is non-destructive. It is useful for acceptance testing; the determination of the effects of aging, staining and redecoration of acoustic materials; and for quality-control purposes in the manufacture of acoustic materials. The results of laboratory measurements on a large number of acoustic tiles and plasters were compared with the results obtained with the standard reverberation-room techniques. Field measurements were made on acoustic plasters. Large variations in the absorption coefficient were observed and ascribed to faulty application and painting procedures. Measurements were made at 512 c/s. A.

534.845.2 : 534.614

2304. Measurement of the propagation of sound in Fiberglas. Z. ESMAIL-BEGUI AND T. K. NAYLOR. *J. Acoust. Soc. Amer.*, **25**, 87–9 (*Jan.*, 1953).

Presents some experimentally determined values of

the attenuation coefficient and the speed of propagation of sound in Fiberglas. The propagation parameters α and β in the equation for a plane wave $p = p_0 e^{j\omega t-(\alpha+j\beta)x}$ are determined by comparing the amplitudes and phases of the sound pressures existing simultaneously at separate points in the Fiberglas. The principle of measurement is similar to that used by Beranek and Scott involving a longitudinal movable probe in a long narrow metal duct filled with rockwool. However, in the redesigned apparatus, edge effects were reduced by using a tube of larger cross-section; wall vibrations were damped by laminated rubber and Masonite walls; and the shunting effect of the longitudinal probe hole was eliminated by the use of transversely inserted microphones. Experimental data were obtained within 1 db for frequencies between 50 and 1000 c/s for two samples of Fiberglas with nominal weights of 9 lb/c/s PF (hard) and 4¼ lb/c/s TWF (soft). The direction of propagation of the sound was normal to the surface of the blanket. For both samples the attenuation increases almost as the square root of the frequency, but the speed of propagation is found to increase almost as the ¼ and ⅓ root of the frequency for the hard and soft samples, respectively. A.

OPTICS . RADIATION . SPECTRA 535

535.23

2305. Note on thermal radiation at low temperatures. D. Bijl. Letter in *Phil. Mag.*, **43**, 1342–4 (*Dec.*, 1952).

It is pointed out that, for radiation enclosed in a cavity of volume 1 cm³, the usual thermodynamic treatment must break down at temperatures of the order of 1°K or below. E. H. SONDHEIMER

535.23 : 536.7

2306. On reversibility and irreversibility in optics. R. C. Jones. *J. Opt. Soc. Amer.*, **43**, 138–44 (*Feb.*, 1953).

Some of the physical operations that can be performed on a beam of light are reversible; others are irreversible. In many situations the distinction is obvious. In other situations, especially where no absorption occurs, it may not be obvious whether a postulated operation is reversible. An experimenter might try to produce a result that is basically impossible of achievement. Fortunately, simple thermodynamic considerations provide a complete interpretation. Thermodynamic considerations are applicable because all sources of visible light are thermal in nature. Planck's formula for blackbody radiation leads directly to once well-known expressions for the temperature and entropy flux of a beam of light of given wavelength, direction, polarization and spectral radiance. By analysing the temperature and entropy changes involved in any given optical operation, the reversibility or irreversibility is easily established. The method is applied to various principal types of optical operations, including those entailing reflecting, condensing, dispersing, diffusing, beam-splitting, polarizing and depolarizing. A.

535.24 : 628.971/2

2307. Colour matching filters for Macbeth illuminometer. M. E. F. Howarth. Letter in *J. sci. Instrum.*, **29**, 414 (*Dec.*, 1952).

Suggests the use of a blue filter on the comparison lamp side and a yellow filter on the test side in a Macbeth illuminometer, so as to overcome the colour difference found when measuring the illumination from gas-filled tungsten lamps. Actual Wratten filters are suggested. If one of the colour filters is combined with a suitable neutral filter, the calibration of the instrument is unaffected. J. W. T. WALSH

535.247.1 : 778.3

2308. Some photographic methods applied to photometry. C. Marsh. *Illum. Engng*, **47**, 571–4 (*Oct.*, 1952).

Describes the technique of finding the distribution of brightness over an extended area by making a series of photographic exposures, each double the one before it. The negatives are processed to produce images in black and white only, with no half-tones. A contour diagram of iso-phot curves can be obtained by printing the negatives in register. The examples shown include a headlight beam pattern, an illuminated road surface, a semi-direct lighting fitting and the brightness pattern given by a wall-type indirect light. J. W. T. WALSH

535.247.4 : 523.75

2309. An isophotal contour densitometer. F. E. Fowler, D. S. Johnson and D. E. Billings. Letter in *J. Opt. Soc. Amer.*, **43**, 63 (*Jan.*, 1953).

In a study of 35 mm photographs of solar prominences and flares it was required to obtain rapidly the contours of equal optical density, corresponding to equal brightness in the object. A rectangular raster on a c.r.t. was imaged simultaneously on the photograph and on a comparison density sample. The transmitted beams passed to two photomultipliers arranged in a bridge and trigger circuit operating a synchronized viewing tube, which showed a facsimile of all densities on the photograph greater than the comparison density. The area within the isophotal contour was measured by a timing circuit. The useful density range was from 0·0 to 2·3 with a discrimination of 0·01. S. T. HENDERSON

535.3 : 535.345 : 535.5

2310. Stepwise transition from wave optics to ray optics in inhomogeneous anisotropic absorbing media. I. Equations for the wave-normals, refractive index and polarization. K. Suchy. *Ann. Phys.* [*Leipzig*] **11**, *No.* 2–3, 113–30 (1952) *In German.*

A "wave-equation" for the electric field vector is derived from Maxwell's equation by the introduction of dyadics to represent polarization and conductivity. When referred to generalized curvilinear orthogonal co-ordinates restrictions must be placed on the spatial variation of the unit vector along a given ray-path. These are denoted curvature conditions, and comprise the first set of approximations. The curvature conditions are satisfied identically with Cartesian co-ordinates. The spatial variation of the electric vector is then described by a time-freed "vector eikonal," a function which is made the basis for the

subsequent development. The second set of approximations are expressed by "polarization conditions." These require that the spatial variation of the orientation and eccentricity of the polarization ellipse shall be small compared with the spatial variation of amplitude. The gradient of the eikonal then serves to define the wave-normal and refractive index, subject to conditions expressing the inhomogeneity of the medium and the initial conditions for the wave. The proper co-ordinate systems for various problems are then discussed. For a stratified medium the Sommerfeld–Runge law of refraction is used.

H. H. HOPKINS

535.31

2311. A note on apparent magnification in out-of-focus images. W. WALLIN. Letter in *J. Opt. Soc. Amer.*, **43**, 60–1 (*Jan.*, 1953).

Gaussian brackets are used to determine the size and position of the circle of confusion in the out-of-focus image of a luminous point. This allows the apparent magnification to be found. The effect of vignetting within the lens is also calculated. R. W. FISH

535.317

2312. The geometric optics of complex image-forming systems. A. W. TRONNIER. *Abhandl. Braunschw. Wiss. Gesell.*, **4**, 58–72 (1952) *In German.*

The general aims of geometric optics are surveyed and fundamental methods of computation of the ray path through a lens system are described. A new method is proposed and is applied to a recent optical design. R. W. FISH

535.317 : 535.247

2313. On the flare of lenses. G. KUWABARA. *J. Opt Soc. Amer.*, **43**, 53–7 (*Jan.*, 1953).

The flare or the stray light in optical systems reduces the image contrast in photography and causes serious errors in photometry. The amount of the flare for small luminous objects was measured by an improved photographic photometry. Generally, the flare originates in two ways, that is, reflections at air-glass interfaces and scatterings by dusts or scratches on glass surfaces. The flare by reflection increases with the area of the illuminated object and attains a saturated value for a large field angle: on the other hand, the flare by scattering slightly depends upon the area. When plotted *v.* the area or the square of the subtended angle of the target, the amounts of the flare lie on a straight line with several kink points, and the flare by scattering can be determined by extrapolating this line to zero field angle. For a small luminous target, the effect of the flare by reflection is less at a higher relative aperture than at a lower, and the anti-reflection coating greatly reduces the reflected light but slightly enhances the scattered light. A.

535.317.4

2314. The wave aberration associated with skew rays. H. H. HOPKINS. *Proc. Phys. Soc.* [*London*] *B*, **65**, 934–42 (*Dec.*, 1952).

It is shown that invariant foci exist for skew rays, and simple formulae are obtained for the change in aberration relative to those foci due to refraction or reflection at an interface. The formulae are valid for any form of interface. Expressions for focal shifts are obtained together with check formulae. The method makes possible the analysis of the aberrations along skew rays as they arise at individual surfaces. A.

535.322.4

2315. A precision recording refractometer. S. E. J. JOHNSEN AND P. D. SCHNELLE. *Rev. sci. Instrum.*, **24**, 26–35 (*Jan.*, 1953).

An instrument is described which measures continuously and records the index of refraction of flowing liquid streams. The instrument is similar to a spectrograph employing a hollow prism through which the sample stream flows. Refractive index is inferred by measuring the position of the refracted beam of monochromatic light projected to form a slit image. Provision is made to compensate the instrument for rapid changes in temperature of the flowing stream of about $\pm 10°C$ on either side of a reference temperature. A.

535.323

2316. Optical constants by reflection. T. S. ROBINSON. Letter in *Proc. Phys. Soc.* [*London*] *B*, **65**, 910–11 (*Nov.*, 1952).

The determination of optical constants n and k of a substance from reflection coefficient ratios at various angles of incidence is difficult in the case of anisotropic substances. The complex refractive index $\mathbf{n} = n - ik$ can be found from reflection measurements taken at normal incidence over a range of frequencies. Results with polythene agree with those obtained by other methods. R. W. FISH

535.323–15

2317. Refractive index of potassium bromide for infrared radiant energy. R. E. STEPHENS, E. K. PLYLER, W. S. RODNEY AND R. J. SPINDLER. *J. Opt. Soc. Amer.*, **43**, 110–12 (*Feb.*, 1953).

The index of refraction of KBr at 22°C has been measured for the infrared region from 1 micron to 25 microns by means of two methods on two different instruments. The two resulting sets of indexes agree to within the probable error of either one except at the two longest wavelengths. A five-constant expression has been found that represents the index as a function of wavelength over the region from 0·4047 microns to 25 microns. Indexes were measured at several of the wavelengths at temperatures higher and lower than 22°C and thermal coefficients of index were computed. A.

535.323–31 : 535.39–31

2318. The optical constants of gold and silver in the ultraviolet. H. KOBER. *Ann. Phys.* [*Leipzig*] **11**, *No.* 1, 12–14 (1952) *In German.*

The constants are determined by a method of Kretzmann (1940) using 4 reflections from evaporated films. For Ag, thickness = 180 mμ, λ = 330–550 mμ. For Au, thickness = 350 mμ, λ = 250–550 mμ. G. F. LOTHIAN

535.33.03

2319. Formation and excitation of atomic sodium in hydrogen diffusion flames. L. LINDNER, W. E. SCOTT AND E. R. STEPHENS. Letter in *J. chem. Phys.*, **21**, 161–2 (*Jan.*, 1953).

The variation of *D*-line absorption in diffusion flames of H_2 with varying amounts of added SO_2

supports the view that the Na is formed by reaction $H + NaX = Na + HX$ and that additives such as SO_2 reduce the Na emission by removing H atoms.

A. G. GAYDON

535.33.03–32 : 536.48

2320. Low temperature spectroscopy in the farther ultraviolet region. W. J. POTTS, JR. *J. chem. Phys.*, **21**, 191–5 (*Feb.*, 1953).

Methods are presented which make possible quantitative spectroscopic measurements at liquid nitrogen temperatures from the visible region to as far as 1670 Å in the ultraviolet region. A.

535.33.07

2321. A photometer and absorption cell attachment for ultramicro-spectrophotometry. R. CRAIG, A. BARTEL AND P. L. KIRK. *Rev. sci. Instrum.*, **24**, 49–52 (*Jan.*, 1953).

A cell holder and photometer for use with the Beckman Model DU spectrophotometer is described. The cell holder is designed to position capillary cells of small diameter, e.g. 0·7 mm, and 5 cm in length in the narrow beam of light passed through fine collimating masks. The capacity of the cells is about 20 mm^3 which allows analysis of quantities about 10 times smaller than have been hitherto analysable. The photometer employs a multiplier phototube in order to achieve the requisite sensitivity for the small amount of light transmitted. A.

535.33.07

2322. A single detector split-beam automatic recording spectrophotometer. H. W. ETZEL. *J. Opt. Soc. Amer.*, **43**, 87–90 (*Feb.*, 1953).

A split-beam system of spectrophotometry is described in which each of the two beams is modulated at a different frequency. A single photomultiplier is used as a detector. Separation and amplification of the two frequencies are effected by tuned amplifiers. Percent transmission *v.* wavelength data is recorded automatically in the region 2050 Å to 4000 Å using a hydrogen discharge lamp, and in the region 3200 Å to 7000 Å using a tungsten lamp as a source. Either of these ranges is scanned in less than ten minutes and the accuracy at an optical density of 2 is about 10%. The optical system of the commercial monochromator used is in no way altered. A.

535.33.07

2323. The measurement of wavelength in echelle spectra. N. A. FINKELSTEIN. *J. Opt. Soc. Amer.*, **43**, 90–6 (*Feb.*, 1953).

Echelle spectrographs produce a two-dimensional array of spectral lines, and therefore present a new problem in the determination of wavelengths. One approach to this problem consists of delineation of the spectrum into its component cyclic orders and the subsequent identification of an unknown spectral line in terms of position within its order cycle, using the spectrographic optical axis as a fiduciary line. A system has been developed for determining the wavelengths of spectral lines in an echellogram produced on the Littrow echelle spectrograph to an accuracy of the order of 1 part in 100 000, an accuracy which is more than sufficient for routine line identification. The principles of the method are applicable to wavelength identification in any two-dimensional spectrum, and additional effort will make possible improvement in wavelength precision. Three methods of applying this system are described as follows: (1) An order grid is superposed on the unknown spectrum and wavelengths are determined by arithmetical interpolation between known lines in the spectrum. A conventional spectrum viewer is used. Each order containing an unknown spectrum line to be determined must also contain at least two lines whose wavelengths are accurately known. For high accuracy, second-order interpolation is necessary. (2) An order grid containing locus lines and optic axis line is positioned on the unknown spectrum. A conventional spectrum viewer is used in conjunction with mental arithmetical interpolation to determine the wavelength of an unknown spectrum line. (3) An order grid containing locus lines and optic axis line is positioned on the unknown spectrum. A conventional spectrum viewer on which the 20 mm scale has been replaced by an interpolation above is used to automatically interpolate positions between the optic axis line and the locus lines. Alternatively, the spectrum can be projected in a viewing box containing the interpolation scale. A.

535.33.07 : 535.339

2324. Reduction of scattered light in a Littrow-type monochromator. A. WALSH. Letter in *J. Opt. Soc. Amer.*, **43**, 58 (*Jan.*, 1953).

A large amount of the scattered light arises when the undispersed beam strikes the collimator and the prism face. If a chopper is located between the prism and the Littrow mirror, this scattered light will not be interrupted and will not be recorded if a tuned amplifier is used. R. W. FISH

535.33.07 : 535.339

2325. Multislit multipass spectrometers. M. J. E. GOLAY. Letter in *J. Opt. Soc. Amer.*, **43**, 58–60 (*Jan.*, 1953).

This letter comments upon a previous multipass monochromator arrangement [Abstr. 7147 (1952)]. The use of a spherical mirror in a multiple monochromator is suggested or alternatively a combination of the dynamic multislit principle with the multipass principle to yield both a many-fold increased resolution and a many-fold increased radiative output.

R. W. FISH

535.33.07 : 535.375.5

2326. Photoelectric Raman spectrometer with automatic range changing. I. Conversion of photographic instrument. R. F. STAMM, C. F. SALZMAN, JR AND T. MARINER. *J. Opt. Soc. Amer.*, **43**, 119–25 (*Feb.*, 1953).

The emphasis in this paper is on the circuitry aspect of the problem of converting a photographic Raman instrument into a photoelectric Raman spectrometer. The reconstructed instrument was tested by using a scanning-slit mechanism in the focal plane of the camera lens of a grating spectrograph. A photomultiplier tube served as the detector and was operated in a vacuum housing at the temperature of liquid nitrogen. A tetrode electrometer tube in a low gain circuit yielded a nearly linear output which was graphically recorded. A spiral mercury arc provided

sufficient illumination to enable reproduction of intensity measurements to within ±1% at a scanning rate of about 3 cm^{-1} per sec. An automatic range changing device extends the range of intensities which can be recorded on the normal 10-in. chart. A.

535.33.07 : 535.375.5

2327. Photoelectric Raman spectrometer with automatic range changing. II. Conversion of Perkin–Elmer infrared instrument to grating type. R. F. Stamm and C. F. Salzman, Jr. *J. Opt. Soc. Amer.*, **43**, 126–37 (*Feb.*, 1953).

A Perkin–Elmer model 12 infrared spectrometer has been converted to a plane grating spectrometer for recording Raman spectra photoelectrically. The light source is a Toronto-type, helical mercury arc which illuminates the sample (either 4·5 or 9 cm^3) contained in a vertical, cylindrical tube. The sample tubes are provided with back-surface, concave mirrors (held in the rear of the tubes and integral with the stoppers) thereby doubling the intensity. The difficulties experienced with grating ghosts are discussed along with the requirements for the grating. The fine structure of the CCl_4 459 cm^{-1} and C_6H_6 992-cm^{-1} lines can be resolved using a 9 cm^3 sample. With reference to 992 of benzene, a signal-to-noise ratio of 120 : 0·15 can be achieved with a time constant of ½ sec and permits spectra to be obtained at a rate of 0·83 cm^{-1} per sec with intensity ratios correct to within ± 1%. A.

535.33.07–15

2328. Infrared properties of cesium bromide prisms. E. K. Plyler and N. Acquista. *J. Res. Nat. Bur. Stand.*, **49**, 61–3 (*Aug.*, 1952).

A CsBr prism has been installed in a Perkins–Elmer spectrometer, and spectra have been observed in the region from 15 to 38 μ. This prism is of better optical quality than those of KRS–5, which makes it possible to obtain sharp images at the second slit of the spectrometer. Measurements have been made with this CsBr prism, which has a refracting angle of 55°, and the results have been compared with those obtained with a 26° KRS–5 prism. The dispersion of CsBr from 15 to 38 μ is about equal to KRS–5, but the effective resolution is about twice as great. A group of rotational lines of water vapour at 28·4 μ is now clearly resolved into three components, the two narrow ones being separated by 1·8 cm^{-1}. The long wavelength bands of carbon disulphide and chloroform have been measured in the vapour state, and it is possible, with the good definition available, to observe the *P*, *Q* and *R* branches. In the spectral region beyond 33 μ, the stray radiation produces a considerable amount of the total deflection. The stray radiation was reduced to one-tenth of its value by the use of a roughened silver mirror located in the source box of the spectrometer. A.

535.33.08

2329. Calibrating wavelengths in the region from 0·6 to 2·6 microns. N. Acquista and E. K. Plyler. *J. Res. Nat. Bur. Stand.*, **49**, 13–16 (*July*, 1952).

The wavelengths of twenty absorption bands have been measured on a grating spectrometer in the region from 0·6 to 2·6 μ. Also, several emission lines of Kr have been measured in the near infrared region. The purpose was to make available additional calibration points for prism instruments. The bands selected for calibration are parts of the absorption spectra of didymium glass, carbon disulphide, 1,2,4-trichlorobenzene and polystyrene. Five graphs of the measured spectra are included, and the calibrated wavelengths are marked on the bands in order to facilitate identification. A.

535.332–15

2330. Infrared spectra of noble gases (12000 to 19000 Å). C. J. Humphreys and H. J. Kostkowski. *J. Res. Nat. Bur. Stand.*, **49**, 73–84 (*Aug.*, 1952).

The first spectra of He, Ne, A, Kr and Xe, excited by discharges in Geissler tubes, operated by direct connection to a transformer, have been explored in the infrared (12 000 to 19 000 Å). A high-resolution, automatically recording, infrared spectrometer, employing a 15 000 lines/in. grating and PbS photoconducting detector, was used as the dispersing instrument. A new set of wavelength values is reported for all these spectra. New data include 18 previously unreported lines of Ne and 36 of Kr, all of which have been classified. The descriptions of the spectra of A, Kr, and Xe represent essentially a repetition of the observations of Sittner and Peck. Several previously missing classifications are supplied, also a few amended interpretations. The analysis of these spectra may be regarded as complete. Use of selected lines as wavelength standards is suggested. A.

535.337

2331. Effect of irradiation on the intensity distribution of the second positive nitrogen bands excited in a nitrogen ozonizer. R. K. Asundi and N. Appalanarasimham. Letter in *Nature* [*London*] **171**, 86–7 (*Jan.* 10, 1953).

535.338 : 539.132/.133

2332. The evaluation of the rotational constants for diatomic molecular levels from perturbation data. III. I. Kovács. *Acta phys. Hungar.*, **2**, *No.* 2, 141–50 (1952) *In German.*

For Pt. II, see Abstr. 7673 (1951). The application of the methods given in II to the determination of the rotational and vibrational constants of both perturbing and of perturbed states is illustrated for bands of BiH, SrO and BaO. The effects of additional terms in the centrifugal stretching constants, *D*, are also considered. R. F. BARROW

535.338.333

2333. Isotope shift in neutral oxygen. L. W. Parker and J. R. Holmes. *J. Opt. Soc. Amer.*, **43**, 103–9 (*Feb.*, 1953).

An O^{18}-enriched oxygen sample has allowed examination of isotope structure in 20 atomic lines between 2000 and 11 000 Å. Strong sharp lines were obtained in a liquid-nitrogen-cooled electrodeless quartz discharge tube containing up to 0·5 mm of oxygen in 5 mm of helium excited by a 10 Mc/s oscillator. The discharge was photographed through an external Fabry–Perot interferometer in series with a large prism spectrograph. The shifts found ranged from zero to as high as 0·5 cm^{-1} for λ4233 ($4p\ ^3P - 3d'\ ^3P$) and λ2884 ($3p\ ^3P - 3d'\ ^3P$). Enough

data was available to allow a study of the internal consistency of the measured shifts as a test of the mass-effect theory. With the measured shifts in two lines, two theoretical parameters for the specific effect were empirically determined and used to predict shifts in several other lines. It is concluded that the mass-effect theory is generally applicable to oxygen and that the abnormally large shifts found for λ4233 and λ2884 are the result of interactions affecting the common upper level. A comparison is made with earlier nitrogen data. Use is made of the formal relationship of specific effect parameters to certain radiation theory integrals in calculating a transition probability and an f value for the λ1306 resonance triplet. The reasonable values obtained are a further indication of the validity of the theory. A.

535.338.334

2334. The effect of collisions upon the Doppler width of spectral lines. R. H. DICKE. *Phys. Rev.*, **89**, 472–3 (*Jan.* 15, 1953).

Quantum mechanically the Doppler effect results from the recoil momentum changing the translational energy of the radiating atom. The assumption that the recoil momentum is given to the radiating atom is shown to be incorrect if collisions are taking place. If the collisions do not cause broadening by affecting the internal state of the radiator, they result in a substantial narrowing of the Doppler broadened line. A.

535.338.4

2335. Studies of the blue bands of SrO. I. KOVÁCS AND Á. BUDÓ. Letter in *Acta phys. Hungar.*, **1**, *No.* 4, 469–70 (1952) *In German.*

Rotational analysis shows that the blue bands ($\nu_{0,0} \sim 24635\ cm^{-1}$) have the same lower state, $^1\Sigma$, as the i.r. and u.v. systems [Almqvist and Lagerqvist, Abstr. 1505 (1953)]. The upper state of the blue bands is $^1\Pi$ with $B_e = 0{\cdot}2934$, $\alpha_e = 0{\cdot}0012$.

R. F. BARROW

535.343–14 : 539.133

2336. The microwave spectrum of $C_8H_{13}Br$ and $C_8H_{13}Cl$. A. H. NETHERCOT, JR, AND A. JAVAN. *J. chem. Phys.*, **21**, 363–4 (*Feb.*, 1953).

The spectrum and structure of the molecules $C_8H_{13}Br$ and $C_8H_{13}Cl$ have been determined. Despite the large size of these molecules, the spectra can be analysed, with the exception of the quadrupole hyperfine splittings which cannot be resolved. The B values are 1090·9 Mc/s for Cl^{35}, 1065·9 for Cl^{37}, 725·9 for Br^{79}, and 718·5 for Br^{81}. The value of the normal single bond carbon–carbon distance is found to be $d_{c-c} = 1{\cdot}545 \pm 0{\cdot}004$ Å. The angle of twist about the symmetry axis is $\phi = 0° \pm 4°$, and the angle between the carbon–carbon and carbon–halide bonds is $\theta = 190°50' \pm 10'$. A.

535.343.2

2337. The 'extra' levels in rare earth salts. H. E. D. SCOVIL AND K. W. H. STEVENS. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 954–5 (*Nov.*, 1952).

The extra levels found in optical absorption spectra might be due to differences in the electrostatic fields for different ions in the crystal. This is suggested by magnetic resonance results with samarium ethyl sulphate, which show 2 lines with similar g-values, the intensity of the weaker one varying from crystal to crystal. W. J. SWIATECKI

535.343.2 : 539.21

2338. On the temperature dependence of the optical absorption of β–Ag_2S. K. LEHOVEC. *J. Chem. Phys.*, **21**, 54–7 (*Jan.*, 1953).

The shift with temperature of the absorption edge for β–Ag_2S was measured on a Ag_2S ingot and a Ag_2S sheet prepared by tarnishing of Ag in sulphur vapour. The measurements indicate a shift in energy of about $-1{\cdot}2$ to $-1{\cdot}9\times10^{-3}$ eV/degree. This value is used to explain the abnormally high value of the numerical factor in front of the exponential term in the expression of conductivity v. temperature. If the change in absorption with temperature is due to the decrease in lattice extension, one should expect a decrease in conductivity with increasing pressure of $(1/\sigma \,.\, d\sigma/dp) \sim -0{\cdot}42/T$ (T in degrees Kelvin, p in atmospheres). In the course of this study the linear expansion coefficients of β–Ag_2S ($15{\cdot}2\times10^{-6}$ per degree) and of α–Ag_2S ($37{\cdot}5\times10^{-6}$ per degree) have been measured. A.

535.343.2–15

2339. The infrared spectra of oriented rhombic sulfur crystals with polarized radiation. G. M. BARROW. *J. chem. Phys.*, **21**, 219–22 (*Feb.*, 1953).

The infrared spectra, in the rock salt region, of oriented sections of single rhombic S crystal have been obtained. The spectra of sections perpendicular to the c axis of the crystal, the 001 type planes, have been compared, under ordinary radiation with those of sections parallel to the c axis, 110 type planes. Most bands in the region investigated, 700 to 1500 cm^{-1}, show differences in intensity in the two spectra. With a 110 section and radiation polarized at various angles, similar changes in intensity were observed. Both experiments lead to similar conclusions regarding the direction of the oscillating dipole in the vibrations giving rise to the observed bands. Assignments of the infrared active species (B_2 or E_1) in these bands are given but no attempt is made to explain them in terms of the fundamental vibrations. A.

535.343.3–15 : 535.375.55 : 536.7 : 539.132

2340. Raman and infrared spectral data, assignments, potential constants, and calculated thermodynamic properties for oxalyl chloride. J. S. ZIOMEK, A. G. MEISTER, F. F. CLEVELAND, AND C. E. DECKER. *J. chem. Phys.*, **21**, 90–100 (*Jan.*, 1953).

Raman displacements, semiquantitative relative intensities, quantitative depolarization factors (single-exposure method), and infrared wave numbers have been obtained for liquid oxalyl chloride (ClOC–COCl) at room temperature. A critical examination of the present and previous data has been made and probable values have been determined. Normal coordinate treatments have been made for both the *cis*- and *trans*-forms. A satisfactory assignment of the present and previous Raman and infrared bands has been made, assuming the sample to be in the *trans*-form. Only binary combinations and 1st overtones were used, except for the 2 highest bands at 3740 and 5140 cm^{-1}. Fermi resonance occurs in 4 cases. Not more than 10% of the *cis*-form can be present, and the presence of even this much rests

solely upon Saksena and Kagarise's reported temperature variation in the intensity of the 533-cm^{-1} Raman band, though the normal coordinate treatment does indicate that the strongest *trans*-Raman line at 620-cm^{-1} could occur near 533 for the *cis*-structure. The moderately polarized resonance triplet 450, 471, 488 can hardly be accounted for by the presence of a polarized fundamental in this region, for either the *cis*- or the *trans*-form. The heat content, free energy, entropy, and heat capacity were calculated (rigid rotator, harmonic oscillator approximation) for 11 temperatures from 100° to 1000°K for the ideal gaseous state at 1 atm. pressure. A.

535.343.32

2341. Regularities in the spectra of molecular complexes. H. McConnell, J. S. Ham and J. R. Platt. *J. chem. Phys.*, **21**, 66–70 (*Jan.*, 1953).

The intense so-called "intermolecular charge-transfer spectra" shown by a large number of molecular complexes in solution are found to exhibit certain regularities in regard to wavelength and intensity. The wavelengths of these transitions show an excellent correlation with the ionization potentials of the electron donor partners of the complexes. The intensities of the charge transfer transitions are markedly dependent on the electron acceptor partner of the complex. These results are examined in terms of possible theoretical interpretations of the charge-transfer transitions. A.

535.343.32–31

2342. On the ultraviolet absorption spectra of uninegative ions. H. L. Friedman. *J. chem. Phys.*, **21**, 319–22 (*Feb.*, 1953).

New spectral data are reported for NO_2^-, ClO_2^- and ClO^- in aqueous solution. The theory of the electron transfer spectra of aqueous halide ions is extended to uninegative polyatomic ions by allowing for the greater excitation energy of the polyatomic radicals produced in the act of absorption, as compared with the excitation energy of the atoms produced from halide ions. This additional excitation energy arises from the operation of the Franck–Condon principle in determining the internuclear distances in the radical. Tri-iodide ion is the only one of the uninegative ions for which the required data are available and for which these data are not consistent with the assignment of the intense ultraviolet bands to transitions involving transfer of an electron to the solvent. It is found that the low intensity absorption bands of NO_2^- and ClO_2^- coincide with the bands predicted by R. S. Mulliken for triatomic oxide molecules (AO_2) with the same numbers of valence electrons. A.

535.343.4 : 535.375.55

2343. The infrared and Raman spectra of SiH_2Cl_2. J. A. Hawkins and M. K. Wilson. *J. chem. Phys.*, **21**, 360–2 (*Feb.*, 1953).

An investigation of the i.r. spectrum of gaseous SiH_2Cl_2 and the Raman spectrum of liquid SiH_2Cl_2 results in the following fundamental assignment:

$\nu_1(a_1)=2200\text{cm}^{-1}$, $\nu_2(a_1)=953\text{cm}^{-1}$, $\nu_3(a_1)=531\text{cm}^{-1}$,
$\nu_4(a_1)=188\text{cm}^{-1}$, $\nu_5(a_2)=710\text{cm}^{-1}$, $\nu_6(b_1)=2200\text{cm}^{-1}$
$\nu_7(b_1)=810\text{cm}^{-1}$, $\nu_8(b_2)=877\text{cm}^{-1}$, $\nu_9(b_2)=592\text{cm}^{-1}$.

Thermodynamic functions for SiH_2Cl_2 were calculated with the usual assumptions. The i.r. spectrum of gaseous CH_2Cl_2 and the i.r. and Raman spectrum of liquid CH_2Cl_2 were remeasured. A.

535.343.4

2344. Distribution of intensities of a continuous absorption spectrum as a function of wave number and temperature. P. Sulzer. *Dissert. E.T.H. Zürich, No.* 2051, 42 *pp.* (1952) *In German.*

The intensity distribution of a continuous absorption spectrum of a diatomic gas is calculated quantum mechanically. If one assumes the absorption curve to be a Gaussian of constant enclosed area, the extinction coefficient can be expressed as a function of temperature, of the maximum extinction value at 0°K, and of the vibration frequencies of the molecule. For the absorption maximum this relation is considerably simplified: the extinction coefficients are reciprocally proportional to the square roots of the average vibration energies at each temperature. The absorption spectrum was measured for iodine. The calculated values were compared with these experimental data and with extinction coefficients previously measured by other authors. There is good agreement. For polyatomic molecules the results of the calculations are of no practical value, if all vibrations are taken into account. If only few vibrations are important (e.g. diphenyl) empirical relations can be derived. A. J. TAYLOR

535.343.4

2345. Absorption spectra of free radicals in continuously irradiated photochemical systems. D. A. Ramsay. Letter in *J. chem. Phys.*, **21**, 165–6 (*Jan.*, 1953).

Using a multiple reflection mirror system, with a quartz mercury lamp, NH_2-bands were observed in the region of 6000 Å, and 40 lines of the (0–0) CN band near 3883 Å. C. TURNER

535.343.4–14

2346. Millimeter wavelength dispersion of water vapor. G. Birnbaum. *J. chem. Phys.*, **21**, 57–61 (*Jan.*, 1953).

Dispersion due to water vapour in the wavelength region ∞ to 0·6 mm is computed by means of quantum mechanical formulae. The dispersion is attributed to: (1) The contributions of the 11 rotational lines in the region considered; these are obtained with a dispersion equation characteristic of collision theory specialized to sharp lines. (2) The combined contribution of all rotational lines of shorter resonance wavelength. This is obtained with the aid of the well-known shape factor $(\nu_n^2-\nu^2)^{-1}$, which is shown to be valid for sharp lines independent of any special model. The strongest line, 3_1–4_{-3}, occurs at 0·794 mm, and it gives rise to a maximum change in susceptibility $\varepsilon'-1$ of $8{\cdot}2\times10^{-6}$ for 1 atmos. of air containing 1% water molecules. The increase in $\varepsilon'-1$ from ∞ to 0·6 mm is about twice this value. If the very small effect of the 1·35 cm line is neglected, a simple equation for $\varepsilon'-1$ holds from ∞ to 2 mm. A.

535.343.4–14 : 539.133

2347. Microwave spectrum and structure of iodosilane. A. H. Sharbaugh, G. A. Heath, L. F. Thomas and J. Sheridan. Letter in *Nature* [*London*] **171**, 87 (*Jan.* 10, 1953).

535.343.4–15

2348. Wavelengths of rotational lines in the water-vapor bands at 0·93 and 1·13 microns. C. C. KIESS. *J. Res. Nat. Bur. Stand.*, **48**, 377–80 (*May*, 1952).

The bands have been photographed with the grating spectrographs of the National Bureau of Standards. These bands appear in absorption in the continuous spectrum of white-light sources, part or all of the optical path being in air. They appear also in emission in the spectra of flames containing hydrogen and oxygen compounds. In relatively short light-paths, the rotational lines of these bands are sharp and show little or no tendency toward diffuseness, even in air for which the relative humidity is 90%. Their wavelengths may be measured with accuracy on high-dispersion spectrograms. Wavelengths, estimated intensities, and wave numbers, as derived from the spectrograms, are presented. The wavelengths are recommended for use in calibrating infrared spectrometers. A.

535.343.4–15

2349. The $3\nu_3$ bands of carbon disulfide and carbon dioxide. N. M. GAILAR AND E. K. PLYLER. *J. Res. Nat. Bur. Stand.*, **48**, 392–4 (*May*, 1952).

This band of CS_2 is complex, containing two transitions from excited states and two transitions attributed to the isotopic molecule $CS^{32}S^{34}$ in addition to the primary transition $000 \rightarrow 003$ of CS_2^{32}. A multiple-reflection cell of 6 m path length, 20 cm optics and negligible loss of aperture is described. Molecular constants are checked for CO_2 and found for CS_2. These latter constants are: $B_0 = 0{\cdot}1089\,cm^{-1} \pm 0{\cdot}0004$, $\alpha_3 = 0{\cdot}0007\,cm^{-1} \pm 0{\cdot}00003$, $X_{33} = -5{\cdot}2\,cm^{-1}$ and $X_{23} = -3{\cdot}3\,cm^{-1}$. A.

535.343.4–15

2350. The infra-red spectra of CF_3Br and CF_3I. S. R. POLO AND M. K. WILSON. Letter in *J. chem. Phys.*, **20**, 1183 (*July*, 1952).

Independent observations are compared with those of Plyler and Acquista [Abstr. 7175 (1952)].

D. H. WHIFFEN

535.343.4–15

2351. Absorption spectrum of water vapor between 4·5 and 13 microns. W. S. BENEDICT, H. H. CLAASSEN AND J. H. SHAW. *J. Res. Nat. Bur. Stand.*, **49**, 91–132 (*Aug.*, 1952).

The spectrum has been measured with a 3600 lines/in. replica echelette grating as the dispersing element. Various absorbing path lengths and concentrations of water vapour at atmospheric pressure were used up to 8 m of steam near 110°C. Almost all of the previously unreported lines that have been found are also present in the solar spectrum. A rotational analysis shows that most of the lines can be assigned either to rotational transitions or to rotation-vibration transitions of the ν_2 fundamental of the water-vapour molecule. In addition, a few lines have also been assigned to the transitions $(2\nu_2 - \nu_2)$, $(\nu_1 - \nu_2)$ and $(\nu_3 - \nu_2)$. A.

535.343.4–15 : 537.375.56

2352. The infrared and Raman spectra of dicyanoacetylene. F. A. MILLER AND R. B. HANNAN, JR. *J. chem. Phys.*, **21**, 110–14 (*Jan.*, 1953).

The preparation of dicyanoacetylene, $D \equiv C - C \equiv C - C \equiv N$, is outlined and its i.r. and Raman spectra are presented. An assignment is given for 8 of the 9 fundamental frequencies which explains the observed combination tones very satisfactorily. All features of the spectra are compatible with $D_{\infty h}$ symmetry, including particularly the i.r. band contours, the lack of coincidences between i.r. and Raman frequencies and the operation of selection rules for the combination tones. Results of a normal coordinate treatment are included. A.

535.343.4–15 : 539.133

2353. Fine structure in some infrared bands of methylene halides. E. K. PLYLER AND W. S. BENEDICT. *J. Res. Nat. Bur. Stand.*, **49**, 1–6 (*July*, 1952).

The infrared absorption spectra of methylene chloride, methylene bromochloride and methylene bromide have been studied with a high-resolution grating spectrometer in the region from 1·6 to 2·3 μ. The purpose of these measurements was to determine the molecular constants of these molecules from their spectra. Using the saturated vapour in a cell 60 cm long, it was possible to resolve the fine structure in three to five bands of each molecule. All the resolved bands are overtones and combinations of fundamental vibrations localized in the methylene radical, and hence appear at nearly the same frequencies for each molecule. Bands with Q branches (symmetry types B and C) and without that feature appear. Application of combination relations to all bands of a given molecule yield rotational spacings of the ground state agreeing within 0·5%. The spacings, $[A'' - (B'' + C'')/2]$, are, respectively: for CH_2Cl_2, $0{\cdot}955\,cm^{-1}$; CH_2BrCl, $0{\cdot}898\,cm^{-1}$; and CH_2Br_2, $0{\cdot}821\,cm^{-1}$. The molecular dimensions cannot be uniquely determined from these data alone, but if tetrahedral angles are assumed, they lead to improbably low values of the C — halogen distance, namely, 1·70Å for C — Cl and 1·83Å for C — Br. If the halogen — C — halogen angle is increased to 112°, as found by electron diffraction, the C — Cl distance is in good agreement with the electron diffraction distance 1·766Å, and C — Br becomes 1·907Å in CH_2Br_2 and 1·911 in CH_2BrCl. A.

535.343.4–32

2354. The far ultraviolet absorption spectra of simple alkyl amines. E. TANNENBAUM, E. M. COFFIN AND A. J. HARRISON. *J. chem. Phys.*, **21**, 311–18 (*Feb.*, 1953).

A quantitative study of the absorption spectra of ammonia, the three methyl and the three ethyl amines, has been made in the region 39 000 to 63 000 cm^{-1}. Three electronic transitions have been observed in most cases. The first is of low intensity particularly in the secondary amines, the second is of higher intensity and increases from the primary to the tertiary compound, and the third, which is only partially covered by these measurements, is of intermediate intensity. The positions of all transitions, particularly the second, are influenced by alkyl substitution. These transitions are discussed in relation to the spectrum of ammonia. Vibrational structure, present in ethyl amine, methyl amine and dimethyl amine, has been analysed in part. A.

535.343.4–32

2355. A third Rydberg series of N_2. R. E. WORLEY. *Phys. Rev.*, **89**, 863–4 (*Feb.* 15, 1953).

A third series of Rydberg bands, converging to the $^2\Pi$ state of N_2^+, has been identified in the far ultra-violet absorption spectrum of nitrogen. Its interpretation substantiates an assignment of vibrational numbers for the $^2\Pi$ state, and indicates that this state is derived from the *o* state of N_2. A.

535.345

2356. The optical absorption of sulfur. A. M. BASS. *J. chem. Phys.*, **21**, 80–2 (*Jan.*, 1953).

The optical absorption of S has been studied in the vapour and liquid state and in solution. These measurements indicate the presence of S_8 ring molecules which disappear at high temperature. The absorption edge in the liquid shifts at the rate of 6·20Å/°C toward longer wavelengths with increasing temperature. It is believed that this displacement is related to the thermal excitation of the vibration levels of the S molecules. A.

535.345 : 535.41

2357. On the reversibility of light rays in stratified media. H. POHLACK. *Ann. Phys.* [*Leipzig*] **11**, *No.* 2–3, 145–54 (1952) *In German.*

It is shown that the transmission of a system of plane-parallel interference films is independent of the direction of propagation of the light only providing the initial and final media have the same absorption coefficients. Hence the principle of reversibility does not apply in other cases. The problem is treated by using boundary conditions and expressing the solutions of the resulting equations in matrix notation. A simple extension of the theory shows that the same results obtain for a pair of interference systems flanking a thick absorbing film in which interference does not take place. H. H. HOPKINS

535.345 : 535.371

2358. Spectral location of the absorption due to solar centers in alkaline earth halide phosphors. H. F. IVEY. Letter in *Phys. Rev.*, **89**, 322 (*Jan.* 1, 1953).

535.345–31

2359. An alkaline solution of potassium chromate as a transmittancy standard in the ultraviolet. G. W. HAUPT. *J. Res. Nat. Bur. Stand.*, **48**, 414–23 (*June*, 1952).

The need for a means of testing the reliability of the photometric scale of spectrophotometers in the ultraviolet region (where glasses are unsuitable) has led to the study of an aqueous solution of potassium chromate having the composition 0·0400 g/litre of K_2CrO_4 in 0·05N KOH. Based on extensive measurements, using photographic, photoelectric and visual spectrophotometry, standard values of spectral transmittancy have been determined for 1·000 and 2·000 cm of solution at 25°C from 220 to 500 mμ. These values have been tabulated along with derived values of absorbancy, molar absorbancy index a_M and $\log_{10} a_M$. The latter values have been compared graphically with those of other observers. Changes in spectral transmittancy with changes in temperature have been determined. The work has also included a study of the effects due to the container bottle and to age of solutions over periods up to 8 years, and a comparison of results obtained with the solution prepared either from K_2CrO_4 or from $K_2Cr_2O_7$ as one of the reagents. A.

535.345–31

2360. The ultraviolet absorption of silver bromide. J. R. ALLEN. *Canad. J. Phys.*, **31**, 218–24 (*Feb.*, 1953).

The photoelectric absorption process in solid insulators is discussed and contrasted with that for free atoms and ions. It is suggested that in substances of high dielectric constant the resultant screening of the field of the remaining positive hole due to the polarization of the material results in a reduction of the absorption coefficient at the spectral edge, and produces a maximum at higher energies. This effect is illustrated by a calculation of the ultraviolet absorption coefficient of AgBr using as a model a Br ion in a hole in a uniform dielectric. The calculated absorption coefficient is found to rise from the edge to a maximum at a wavelength of about 850Å. A.

535.345.6

2361. Data for the design of a birefringent filter. L. BERTI. Note in *Nuovo Cimento*, **9**, 304–11 (*March*, 1952) *In Italian.*

A quartz plate, parallel to the optical axis and placed between two polaroids at 45° with its slow and fast axes, causes interference phenomena in polarized light that may be used for obtaining filters suitable for suppressing some spectral lines, when this is impossible by means of common glasses. In this paper the behaviour and the features of these filters are studied. A highly monochromatic Lyot filter, built for studying the sun, is also mentioned. A.

535.361.2–15

2362. The absolute spectral diffuse reflectance of magnesium oxide in the near infrared. C. L. SANDERS AND E. E. K. MIDDLETON. Letter in *J. Opt. Soc. Amer.*, **43**, 58 (*Jan.*, 1953).

Measurements are made at wavelengths up to 2·4 μ. It is found that the reflectance decreases gradually from 0·97 at 0·6 μ to 0·94 at 2·4 μ, with absorption bands at 1·4 μ, 1·9μ and 2·35 μ. The reflectance decreases slowly with time, the value at long wavelengths falling to 0·92 after five days. D. G. AVERY

535.371

2363. On the mechanism of scintillations in solutions. M. AGENO AND R. QUERZOLI. *Nuovo Cimento*, **9**, 282–90 (*March*, 1952) *In Italian.*

A source of fluorescent radiation, intense enough to be photographed, has been made by immersing a source of α-particles in a 5% solution of terphenyl in xylene. From a set of photographs of such a source in different experimental conditions, a direct experimental proof has been carried out for the first time: (*a*) of the energy transport through a range of some millimeters, into a scintillating solution excited by high-energy radiations; (*b*) of the excitation energy transfer from solvent to solute. It has also been demonstrated that this energy transfer is effected, at least partially, by radiation. A.

535.371

2364. Capture and recapture of electrons in phosphorescence. D. CURIE. *Ann. Phys.* [*Paris*] **7**, 749–801 (*Nov.–Dec.*, 1952) *In French.*

Study of phosphorescence curves for ZnS and CaS

suggests a monomolecular decay mechanism. A bimolecular process is indicated by photoconductivity but this has a negligible effect on the phosphorescence process. Thermal glow curves are analysed to give a number of Gaussian curves with relative amplitudes dependent on conditions of the experiment, such as temperature. By i.r. stimulation a large amount of retrapping is found. A theoretical attempt is made to relate the monomolecular decay process to the bimolecular conduction process and to show the influence of the spatial relation between electron traps and luminescence centres. G. F. J. GARLICK

535.371

2365. Polarization of fluorescence of diphenyl and of tetraphenyl-1144-butadiene. P. PESTEIL. *C.R. Acad. Sci.* [*Paris*] **235,** 1384–5 (*Dec.* 1, 1952) *In French.*

535.371

2366. Fluorescent coatings and films with polyvinyl alcohol as a protective medium and binding material. F. ECKART. *Ann. Phys.* [*Leipzig*] **11,** *No.* 2–3, 169–74 (1952) *In German.*

Fluorescent coatings are described which use polyvinyl alcohol instead of water glass as a binding material. The coatings have good mechanical properties and light output. Details of manufacture and test figures are given. R. W. FISH

535.371

2367. The mechanism of acetone vapor fluorescence. H. J. GROH, JR, G. W. LUCKEY AND W. A. NOYES, JR. *J. chem. Phys.*, **21,** 115–18 (*Jan.*, 1953).

The decay rates for the fluorescence of acetone vapour have been determined at several temperatures and pressures, and in the presence and absence of foreign gases, particularly O. The quenching of the fluorescence has also been studied over a similar range of conditions. Since both the presence of O and an increase in temperature tend to eliminate the fluorescence from one of the upper states, it has proved possible to obtain rate constants for the state not so eliminated. Approximate constants for the other state may be obtained by use of the data on total fluorescence in conjunction with data on the temperature and O insensitive state. The data indicate that these two states are formed by independent or nearly independent paths so that molecules in one state are not transformed into molecules in the other under the conditions of these experiments. A consideration of this and previous work permits a further elucidation of the fluorescence phenomena. A.

535.371

2368. Electron traps in the thallium-activated potassium chloride phosphor. P. D. JOHNSON AND F. E. WILLIAMS. *J. chem. Phys.*, **21,** 125–30 (*Jan.*, 1953).

The effects of activator concentration, added impurities, infrared stimulation and temperature of excitation on the thermoluminescence of KCl : Tl permit the identification of the two principal trapping levels as the $^3P_0^0$ and $^3P_2^0$ states of isolated Tl^+. The energy of activation necessary to fill these metastable states, following excitation to the $^3P_1^0$ and $^1P_1^0$ states, is provided by the polarization energy. The concentration of traps simultaneously filled is limited primarily by re-excitation of metastable Tl^+. *F* and *V* centres are created by multiple excitation of Tl^+. These interpretations are quantitatively correlated by a configuration coordinate model and are shown to be in accord with the band theory. A.

535.371

2369. An investigation of the thermoluminescence of fluorite colored by X-ray irradiation. J. J. HILL AND J. ARON. *J. chem. Phys.*, **21,** 223–8 (*Feb.*, 1953).

The thermoluminescence resulting when CaF_2 crystals coloured by X-ray irradiation are heated, has been investigated in the region from 3200 to 6500Å. First, the form of the emission spectrum was determined by the use of a spectrophotometer in conjunction with a photomultiplier tube as a detector, and fifteen emission bands were observed of which seven weak ones had not previously been reported. The peaks of these bands occurred at 3430, 3650, 3710, 3790, 3810, 4150, 4270, 4370, 4570, 4780, 4890, 5230, 5350, 5430 and 5740Å. Second, continuous annealing curves or "glow curves" were obtained for the strongest emission bands by raising the temperature of the crystal at a constant rate and recording the intensity of the emitted light at the peak of each band. The maxima of the glow curves thus recorded fall into two groups. In group 1, three maxima located at approximately 197, 285 and 310°C were observed. In group 2, five intensity maxima could be distinguished, the lowest occurring at approximately 70°C and the highest at 245°C. The corresponding activation energies were calculated, and in two cases were checked by carrying out the annealing at fixed temperatures. These results are consistent with the assumption that two distinct types of imperfections are responsible for the thermoluminescence of CaF_2. The optical absorption appears to be the result of the imperfections associated with group 2. A.

535.371.07

2370. Performance of Lucite-bonded alpha-scintillation screens. J. D. GRAVES, L. A. WEBB AND R. H. DAVIS. *Nucleonics*, **10,** 68–70 (*Dec.*, 1952).

A method is described for producing screens of ZnS and other suitable phosphors, pressed into one side of a Lucite backing and coated with a very thin Al film to form a light-tight cover, through which α-particles may pass with only slight attenuation. The behaviour of these screens with Pu α-particles, is compared with that of normally deposited screens. L. R. SHEPHERD

535.371.1

2371. Temperature dependence of willemite luminescence. E. NAGY. *Acta. phys. Hungar.*, **2,** *No.* 1, 89–92 (1952).

The decrease in luminescence with temperature for willemite and some other phosphors at high temperatures is shown to depend quantitatively on the impurity activator concentration. G. F. J. GARLICK

535.371.1

2372. An improvement on the compensating method for measuring the rise and decay of luminescence. I. P. VALKÓ AND G. GERGELY. *Acta phys. Hungar.*, **2,** *No.* 3, 261–3 (1952).

535.375.1

2373. Unusual phosphorescence of a diamond. J. F. H. CUSTERS. *Physica*, **18,** 489–96 (*Aug.–Sept.*, 1952).

This was found in research on type I and II diamonds. This phosphorescence is excited by short-

wave u.v. light and it is quenched very rapidly by long-wave u.v. A spectrum of the phosphorescence has been taken which shows maxima at 4665, 5310 and 5720Å respectively. It is suggested that there might exist two different types of type II diamond which is the type transparent in the far u.v. Type II*b* will phosphoresce when excited by far u.v. radiation and it will show high electrical conductivity whereas type II*a* will neither phosphoresce in the far u.v. nor show high conductivity. A.

535.375.54

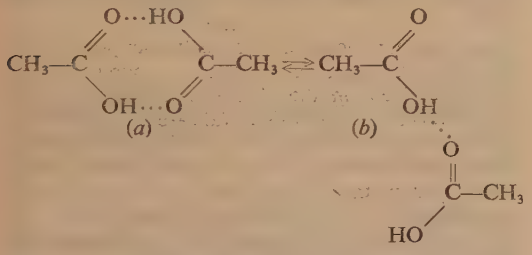
2374. The Raman spectrum of hydrated barium chloride ($BaCl_2.2H_2O$). A. GALY. *C.R. Acad. Sci.* [*Paris*] **235,** 1504–6 (*Dec.* 10, 1952) *In French.*

The frequency, intensity and type of the observed lines are tabulated and the orientation of the water molecules in the crystal discussed. G. I. W. LLEWELYN

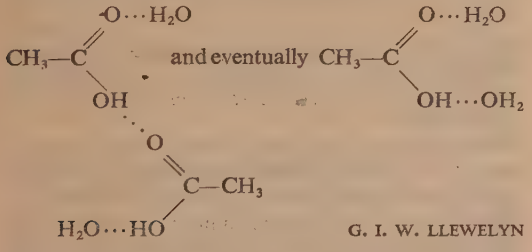
535.375.55

2375. The Raman spectra of solutions of acetic acid in water. S. FÉNÉANT. *C.R. Acad. Sci.* [*Paris*] **235,** 1292–5 (*Nov.* 24, 1952) *In French.*

The Raman spectra of water, acetic acid, and of solutions of seven different concentrations are schematically represented and discussed. The equilibrium between the two dimeric forms



seems to be displaced to the right as the concn. of water increases. This is believed to be caused by fixation of B molecules through hydrogen bond formation with water molecules to give



G. I. W. LLEWELYN

535.376

2376. Energy dependence of scintillating crystals. G. J. BRUCKER. *Nucleonics,* **10,** 72–4 (*Nov.,* 1952).

The results of an experimental investigation in which the light output of various scintillation crystals to X-rays of different energies in the range 30 to 250 keV, were compared with the response of an air ionization chamber. Crystals tested included anthracene, Ag-activated NaCl and KBr, Tl-activated CsBr, KI, CsI and unactivated CaF_2, KBr, NaI and KI. In all cases the responses agreed fairly well with those calculated from the photoelectric and Compton absorption in the crystal materials, except for a reduction in the response of anthracene at the lower energies. This could be attributed to decreased light efficiency with densely ionizing low-energy secondary electrons. L. R. SHEPHERD

535.376

2377. The design of liquid scintillation cells. R. L. GARWIN. Note in *Rev. sci. Instrum.,* **23,** 755–7 (*Dec.,* 1952).

By using a new scintillation liquid, 3 g terphenyl and 10 mg diphenylhexatriene per litre phenylcyclohexane, higher efficiency is obtained, the spectrum being a closer match to the photomultiplier. The liquid does not appreciably dissolve Lucite and there is no fall in counting efficiency in this event. Several designs of cells for this liquid are given with high light collection efficiencies. G. F. J. GARLICK

535.376

2378. A slow component in the decay of the scintillation phosphors. J. A. JACKSON AND F. B. HARRISON. Letter in *Phys. Rev.,* **89,** 322 (*Jan.* 1, 1953).

Phosphorescence of duration $>0{\cdot}5\ \mu$sec is measured relative to emission at shorter time for different scintillators using X-ray excitation. Terphenyl in toluene has 0·1% emission after 0·5 μsec, while other values are terphenyl crystal 2·5%, stilbene 4·3%, anthracene 5·6% and sodium iodide 5·0%. G. F. J. GARLICK

535.376

2379. Absolute light emission efficiency of crystal anthracene for gamma-ray excitation. M. FURST, H. KALLMANN AND B. KRAMER. *Phys. Rev.,* **89,** 416–17 (*Jan.* 15, 1953).

The absolute light emission efficiency of crystal anthracene has been reported in the range from ½ to 4% and in the vicinity of 10%. Further determinations involving integrated light intensity measurements are reported here, which give an efficiency of about 10%. The possibility of the discrepancies being due to the use of peak height measurements in one set of experiments and integrated intensities in the others is discussed; preliminary experiments indicate that the difference in range of values is not due to this cause. A.

535.376

2380. Induced conductivity in luminescent powders. II. A.C. impedance measurements. H. KALLMAN, B. KRAMER AND A. PERLMUTTER. *Phys. Rev.,* **89,** 700–7 (*Feb.* 15, 1953).

See Abstr. 7194 (1952). Alternating current measurements of the impedance changes induced by u.v., i.r., X-ray and γ-ray irradiation in (Zn : Cd)S luminescent powders are reported. These results are in agreement with previously reported d.c. measurements, and indicate that the observed impedance changes are primarily due to the change of the electron density in the conductivity band. Whereas the capacity changes show a monotonic increase, the Q values (X/R) show a pronounced minimum with increasing intensity. A model consisting of radiation sensitive and nonsensitive powder portions is proposed, and theoretical calculations based on such a model are shown to be in agreement with most of the experimental results. This a.c. measurement technique can be used to measure small exciting intensities (down to almost 1/1000 erg/sec cm²). A.

535.39

2381. The reflection and transmission of a multi-layer film. K. Ishiguro and T. Katô. *J. Phys. Soc. Japan*, **8**, 77–81 (*Jan.–Feb.*, 1953).

From the recurrence formula of Weinstein a matrix equation is derived connecting the amplitudes of electric vector of light in the kth layer with those in the pth layer of a multi-layer film. The elements of the matrix are expressed as functions of the reflection and transmission of the intermediate film between the media k and p. From this equation, formulae are derived for the transmission and reflection of an arbitrary multi-layer filter as functions of the thickness of the spacing layer. The results are found to be of the same form as Abelè's equations derived by the consideration of the multiple reflections in the spacing layer. By these equations, the physical meaning of the complicated phase factor of Vašiček's equation is made clear and some new relations of the intensity and phase of the transmitted and reflected light are obtained. A.

535.41

2382. A graphical demonstration of white light interference. A. C. Traub. *Amer. J. Phys.*, **21**, 75–82 (*Feb.*, 1953).

A teaching device is described which can be used in lectures on the interference of white light. The wave forms of four selected components of white light, in the violet, green, yellow and red regions, are shown one above the other on a cardboard chart, inked in their respective colours. A sheet of clear plastic with an identical set of waves drawn on it is placed over the chart so that the two sets are in register. The combination represents a beam of white light as it arrives at the retina. A retardation of part of the beam is illustrated by displacing the plastic sheet laterally. Since the sine waves differ among themselves in wavelength, the various phase changes which result among the four components are shown quite clearly. The principle has been embodied in slide rule form with the wave trains appearing at a large plastic window. Five smaller windows indicate, respectively, path difference in millimicrons, dominant wavelength and purity of the resulting light when C.I.E. Illuminant C is used, and relative energies and resultant hue for the four components shown. A.

535.417

2383. A generalized vector theory of the Mach–Zehnder interferometer. F. D. Bennett and G. D. Kahl. *J. Opt. Soc. Amer.*, **43**, 71–8 (*Feb.*, 1953).

The vector theory of the ideal, planar, Mach–Zehnder interferometer is extended to include three-dimensional models based on geometry of the ellipsoid. Necessary and sufficient conditions for production of white light fringes are determined, and the path difference formula governing interference is developed as in the planar case. Expressions for fringe width and orientation are found and the effects of various source points determined. The problem of optimum source is found reducible to that already treated for the planar interferometer. The effect of a thick plane-parallel plate on a parallel beam is studied. An actual thick plate interferometer is represented as an ideal, ellipsoidal interferometer with the effects of thick plates linearly superposed. Conditions are investigated for obtaining perfect plate compensation; these reduce the ellipsoidal interferometer to plane, parallelogram form. Tests for alignment of a thick plate instrument are suggested. Finally terms accounting for thick windows and compensating chambers are considered. A.

535.417 : 539.211

2384. An interferometric examination of polished diamond surfaces. E. M. Wilks. *J. Opt. Soc. Amer.*, **43**, 84–9 (*Feb.*, 1953).

Multiple-beam interference techniques have been applied to the examination of polished diamond surfaces. Two stones were polished using normal and experimental techniques, but neither stone could be polished to the same standard as a high grade glass optical flat. On one stone it was possible to obtain an area of 5 sq mm which was flat to within $\lambda/40$. The surfaces of both stones, at all stages, showed polish marks, and these were not eliminated even with prolonged polishing. A.

535.42

2385. Note on the diffraction of light by a finite number of centres distributed at random. C. C. Grosjean. *Nuovo Cimento*, **9**, 220–34 (*March*, 1952).

After having shown how a particular problem of light diffraction can be reduced to a purely mathematical problem in the Fresnel representation, the author considers the most general case and establishes exact recurrence relations involving the defined probability functions. These equations are solved exactly and in the isotropic case, the solutions are identical with those of the random flight theory. In practice, however, the solutions are only applicable to the cases where N, the number of centres, is small. For large N, the solutions can be approximated by Gaussian curves. Finally, the results are applied to a one- and a two-dimensional problem. A.

535.42

2386. The Zernicke circle polynomials occurring in diffraction theory. A. B. Bhatia and E. Wolf. Letter in *Proc. Phys. Soc.* [*London*] *B*, **65**, 909–10 (*Nov.*, 1952).

The Zernicke polynomials, which play a fundamental role in recent diffraction research, form a complete orthogonal set for the interior of the unit circle. There exist an infinite number of such complete orthogonal sets, and this note formulates a uniqueness theorem on the Zernicke polynomials. From this theorem and the properties of the Jacobi polynomials, explicit expressions for the Zernicke polynomials and their corresponding generating function are obtained.

R. W. FISH

535.42 : 523.161 : 551.593.5

2387. The Mie theory of diffraction through dielectric spheres with absorbing cores and its application to problems of interstellar matter and of atmospheric aerosols. A. Güttler. *Ann. Phys.* [*Leipzig*] **11**, *No.* 2–3, 65–98 (1952) *In German.*

The theory is developed for dielectric spheres of diameter D with absorbing cores of diameter qD.

Numerical computation is completed for $D \ll \lambda$ for water drops with iron cores through the visible spectrum for $q = 0, 0{\cdot}2, \ldots 1{\cdot}0$. Tables permit calculation of scattering factor (S) and extinction factor (E) (ratios of scattering and extinction cross-sections respectively to geometric cross-section) and albedo ($\gamma = S/E$). The reddening of certain stars could be explained by such particles having $D = 10\ \mathrm{m}\mu$ and $q = 0{\cdot}4$, but the γ of such an interstellar atmosphere would not correspond to measured values. S, E and γ are also plotted as functions of q for atmospheric drops with cores of quartz, graphite and carbon (for $D = 25\ \mathrm{m}\mu$ and $\lambda = 500\ \mathrm{m}\mu$).

G. F. LOTHIAN

535.42 : 534.321.9

2388. On the propagation of narrow light beams in liquids traversed by ultrasound. F. PORRECA. *Nuovo Cimento*, **6**, 274–81 (*March*, 1952) *In Italian.*

The thickness of the beam is of the same order of magnitude as the u.s. wavelength. In these conditions the diffraction fringes due to the u.s. phase grating disappear and in their place appears an enlarged image of the slit. The change of the intensity along this figure, certain conditions of the experiment being equal, should depend only on the form of the u.s. wave. A remarkable difference is found to exist between the liquids examined. A.

535.421

2389. On the production of diffraction gratings. II. The generation of helical rulings and the preparation of plane gratings therefrom. R. G. N. HALL AND L. A. SAYCE. *Proc. Roy. Soc. A*, **215**, 525–49 (*Dec.* 22, 1952).

For Pt I, see Abstr. 6149 (1951). Describes the development at the National Physical Laboratory of Merton's method (1950) of ruling helical diffraction gratings and of transferring them to plane surfaces. It is shown that the periodic errors inevitable in lathe-cut screw threads can be completely eliminated from helices up to 15 000 threads per inch and that by applying the replica process already described, each helix can yield an unlimited number of ghost-free plane gratings. It is also shown that by ruling a grating as one continuous helical groove it is easy to control the distribution of the diffracted energy and to avoid the casual errors which are commonly produced by reciprocating ruling engines. A.

535.43

2390. Scattering of light from small drops. R. L. LANDER AND C. E. NIELSEN. *Rev. sci. Instrum.*, **24**, 20–2 (*Jan.*, 1953).

Curves are given for the angular distribution of light scattered from drops of radius $1{\cdot}4 \times 10^{-3}$ cm and $4{\cdot}8 \times 10^{-4}$ cm for angles from 28° to 147°. The distribution is more nearly symmetrical than had been speculated and depends strongly on the drop size. The intensity of the scattered light was measured with a phototube circuit and galvanometer. The drops were produced in a downward diffusion chamber. A.

535.43 : 519.2 : 541.64

The statistics of stiff chains, with applications to light scattering. *See Abstr.* 2799

535.55

2391. Photoelastic study of breakage. F. ZANDMAN. *C.R. Acad. Sci.* [*Paris*] **235**, 1472–4 (*Dec.* 10, 1952) *In French.*

The results obtained by breaking a methyl methacrylate test-piece of rectangular cross-section are given. The test-piece was placed on two supports, hit with a hammer and the photoelastic picture photographed. The stages from impact to breakage are described. See also Abstr. 8276 (1951) and Abstr. 7611 (1952). H. G. JERRARD

535.566.1

2392. The rotativity of water vapour. R. DE MALLEMANN. *C.R. Acad. Sci.* [*Paris*] **235**, 1263–4 (*Nov.* 24, 1952) *In French.*

The experimentally determined value of the Verdet constant of water vapour, $\Lambda_0^{760} = 9{\cdot}1\ \mu\mathrm{m}$ ($\lambda = 578\ \mathrm{m}\mu$), agrees well with the value calculated using the observed molecular rotation of the liquid.

G. I. W. LLEWELYN

535.6

2393. Colour in theory and practice. Edited by H. D. MURRAY. *London, Chapman and Hall*, 360 + xiii *pp.*

Review in *Brit. J. appl. Phys.*, **3**, 396 (Dec., 1952). "Colour is treated under three main headings, physical and chemical aspects, physiological and psychophysical aspects, and light sources and colorimetry."

535.61–31

2394. Ultraviolet radiation. L. R. KOLLER. *New York, John Wiley* (1952) 270 + ix *pp. Figs.* 148.

Review in *Rev. sci. Instrum.*, **24**, 58 (Jan., 1953). "Appears to be aimed at those people in many fields who are relatively unacquainted with the subject of ultraviolet radiation but who have occasional need for information about it."

535.65

2395. Three-dimensional color models constructed on the CIE and Munsell systems. F. W. BILLMEYER, JR AND A. C. WEBBER. *J. Opt. Soc. Amer.*, **43**, 69–70 (*Feb.*, 1953).

A model of the Munsell colour has been constructed. It differs from the models of a psychological colour solid described by Nickerson and Newhall in that the value planes are thin sheets of transparent Lucite acrylic resin spaced apart from one another. This allows small transparent coloured samples to be placed on the model at approximately their correct colour co-ordinates. A similar model has been constructed on the CIE system. A.

535.7 : 612.84

Physiological optics. *See Abstr.* 2862–4

535.822.9

2396. On phase-microscopic images (general theory). J. HORI. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 29–50 (*Feb.*, 1951).

The vector method, which has hitherto been used to estimate the degree of contrast of phase-microscopic images, can only be applied to sufficiently small objects. It is shown that, if the phase plate is idealized to some extent the vector method can be generalized to enable one to calculate the contrast

of the image for objects which have arbitrary (finite) dimension. By means of Fourier-transformation the intensity distribution of the phase-microscopic image of transparent objects can be calculated. This method leads to a vectorial calculation, whose relation to the ordinary vector method is explained. The interrelation between the contrast of image, width of the ring of the phase-plate and the dimension of the object is discussed, with recourse to a few examples of calculation. A.

535.822.9

2397. On the modified form of phase-contrast microscope. T. HORI AND J. HORI. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 51–6 (*Feb.*, 1951).

Recently one of the authors succeeded in converting the ordinary microscope into a phase-contrast one by a simple method. The underlying principle and the technical procedure of conversion are explained. A.

HEAT 536

536.21

2398. Temperature distribution at the end of a hot wire. J. A. PRINS, J. SCHENK AND J. M. DUMORÉ. *Appl. sci. Res. A*, **3**, *No.* 4, 272–8 (1952).

The end cooling by longitudinal conduction in electrically heated wires has an appreciable influence on the temperature distribution near the end and also on the total heat balance. The relation between temperature and distance from the end is given by a differential equation that in the present article is reduced to its simplest form by the introduction of dimensionless numbers. For some special cases the equation is solved numerically and the result compared with experiment. The method allows a rapid orientation regarding the temperature distribution and the end losses in most practical cases. A.

536.21

2399. On the thermal conductivity of soil. A. HIGASHI. *J. Fac. Sci. Hakkaidô Univ. II*, **4**, 21–8 (*Feb.*, 1951).

Using Ångstrom's method, a new apparatus for measuring the thermal diffusivity of soil was designed. In order to give a boundary condition, the apparatus was constructed to change the applied voltage of a heater. The Slidac and a special cam was used for this purpose. The specific heat of soil was measured by the method of mixture. Thermal diffusivity of a volcanogeneous soil was measured with respect to the water content. Thermal conductivity was calculated from the diffusivity and the specific heat thus obtained. A.

536.21 : 536.48

2400. The thermal conductivity of some polycrystalline solids at low temperatures. R. BERMAN. *Proc. Phys. Soc.* [*London*] *A*, **65**, 1029–40 (*Dec.*, 1952).

The thermal conductivities of polycrystalline alumina, beryllia and graphite have been measured between 2°K and room temperature. The first two are dielectric solids but, even in the graphite specimens, the electronic contribution to the heat conduction is very small. It is shown that the phonon mean free path is limited by scattering at the crystallite boundaries at sufficiently low temperatures. For sintered specimens of alumina and beryllia, in which the density is near the single crystal value, it appears that the mean free path can become greater than the crystallite size. On the other hand there is no evidence that the mean free path can increase above the crystallite size in the graphite specimens, although in this case the interpretation of the results is more difficult. As a consequence of this restriction on the mean free path, graphite specimens with small crystallites are extremely good heat insulators at low temperatures, being better than a glass at temperatures below 5 to 10°K. A.

536.21 : 537.32 : 537.312.6

Thermal conductivity, electrical resistivity, and thermoelectric power of graphite. *See Abstr.* 2463

536.212 : 536.48

2401. Note on the convergence of the Kroll method. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 65–9 (*Feb.*, 1951).

See Abstr. 6948 (1949). The behaviour of the Kroll solution of the Bloch integral equation was studied at extreme low temperatures. A.

536.23

2402. A method for the determination of the thermal conductivity of gases at high pressures. A. MICHELS AND A. BOTZEN. *Physica*, **18**, 605–12 (*Aug.–Sept.*, 1952).

A description is given of an apparatus, based on the parallel plate method, for the determination of the thermal conductivity of gases at elevated pressures. The design of the instrument is described and an account is given of the method of calculating the conductivity coefficient from the experimental data. The accuracy achieved is about 1%. A.

536.24

2403. Possibilities of model investigation in heat conduction research. K. H. BROKMEIER. *VDE-Fachber.*, **15**, 134–7 (1951) *In German.*

Various machines and models for the solution of heat transfer problems and based on the analogy between electrical, magnetic and thermal field distributions, are briefly described and discussed. The limitations are mentioned. S. WEINTROUB

536.24

2404. Heat transfer in laminary flow between parallel plates. J. A. W. VAN DER DOES DE BYE AND J. SCHENK. *Appl. sci. Res. A*, **3**, *No.* 4, 308–16 (1952).

The heat transfer from a liquid in Poiseuille flow between parallel flat boundary walls to its surroundings has been calculated previously for walls of infinite heat conductivity. In the present article the heat transmissivity of the wall k is comparable with that of the liquid λ/D. For two values of their dimensionless ratio, $Nu' = kD/\lambda$, equal to 2 and 20, the temperature distribution and the heat transfer are calculated. The graphs obtained allow interpolation over the whole region from $Nu' = O$ to ∞. The results will apply to practical ducts with very flat cross-section. The mathematical method may be extended to the corresponding, slightly different eigenproblem for the case of a duct with circular cross-section. A.

536.24 : 541.183

Phase transitions in multimolecular layers of adsorbed nitrogen. *See Abstr.* 2796

536.413

2405. The thermal expansion of solids. J. S. DUGDALE AND D. K. C. MACDONALD. *Phys. Rev.*, **89**, 832–4 (*Feb.* 15, 1953).

Under appropriate conditions, the thermal expansion of a solid is closely related to the Grüneisen parameter γ. This in turn may be derived from the variation of the characteristic frequency of the lattice with volume. If, however, this variation is calculated from the usual expressions for the velocity of sound in solids at zero pressure, the γ does not agree with that predicted from lattice theory, and an anomalous thermal expansion is predicted for a solid with a purely harmonic atomic potential. General expressions for the dependence on volume of the velocity of plane waves in one-, two- and three-dimensional lattices are obtained, and hence the corresponding Grüneisen γ's. The three-dimensional γ differs by a numerical constant from that used by Slater. All three expressions are now consistent when applied to a body with a purely harmonic atomic potential and predict no thermal expansion. A.

536.423.15

2406. A semiempirical equation for the vapor pressure of liquids as a function of temperature. A. A. FROST AND D. R. KALKWARF. *J. chem. Phys.*, **21**, 264–7 (*Feb.*, 1953).

The slight reverse curvature in the plot of $\log P$ *v.* $1/T$ (P, vapour pressure; T, absolute temperature) may be explained on the basis of the nonideal behaviour of the vapour together with the change in heat of vaporization with temperature. If it is assumed that ΔH is linear with T and that the van der Waals a/V^2 term is a first approximation to the deviation from the ideal, the following equation may be obtained by integration of the Clapeyron equation: $\log P = A + (B/T) + C \log T + D(P/T^2)$. The last term in the nonideal gas correction with constant $D = a/2{\cdot}303R^2$. With constants A. B and C determined empirically, the equation reproduces experimental vapour pressures from the triple point to the critical point with an average deviation of 0·3%. A.

536.424

2407. Second-order transitions and critical phenomena. R. L. SCOTT. *J. chem. Phys.*, **21**, 209–11 (*Feb.*, 1953).

Second-order transitions occur when a system which is completely ordered at low temperatures (degree of order $s = 1$) changes gradually to a disordered state, ultimately reaching $s = 0$ at the critical or Curie temperature T_c. Elementary theories always predict that $s^2 \propto (1 - T/T_c)$, and predict limiting heat capacities at T_c which are finite and much smaller than those observed. Experimental data on liquid-liquid and liquid-vapour critical phenomena fit a relation in which the cube of s, not the square, is proportional to $1 - T/T_c$. A crude argument, using this empirical equation, leads to the conclusion that the heat capacity rises sharply, probably reaching infinity at the Curie temperature. Experimental data on ammonium chloride and on quartz fit a relation in which the anomalous heat capacity is proportional to an inverse power of $(1 - T/T_c)$. A.

536.46

2408. Rates of combustion of solid fuel particles. G. A. E. GODSAVE. Letter in *Nature* [*London*] **171**, 86 (*Jan.* 10, 1953).

When the temp. of the particle surface is greater than about 850°C, the rate of burning is determined by the rate of mass-transfer of O_2 through the gas-film surrounding the particle. Using Frössling's semi-empirical relation for such mass-transfer it is shown that the reaction rate for C spheres in air at 1200°C is given by $Sd/\rho D = 0{\cdot}347\ (1 + 0{\cdot}272Re^{\frac{1}{2}})$ where S is the specific reaction rate, d the particle dia., ρ gas density, D the diffusion coeff. of O_2 in the gas film and Re the Reynolds number. Little change in the above equation results as gas-temp. varies between 800–1400°C, but the numerical coeff. (0·347) is directly proportional to the partial press. of O_2 in the main gas stream. A. SCHOFIELD

536.46 : 535.33.03

2409. Rotational and vibrational "temperatures" of CH in flames at atmospheric pressure. H. P. BROIDA. *J. chem. Phys.*, **21**, 340–6 (*Feb.*, 1953).

Spectra of the R branch of the $^2\Delta - {}^2\pi$ transition of CH have been obtained from flames of acetylene, propane and methane premixed with oxygen burning at atmospheric pressure. The distributions of rotational and vibrational intensities have been measured and compared with those expected from thermal excitation. Although in some flames the distributions are close to thermal, the majority of distributions indicate that the excited CH is formed by a non-thermal process and is unreliable as a temperature indicator. The suppression of predissociation of CH in rich hydrogen flames with added acetylene has also been investigated. A continuous emission reaching a maximum near 4000Å has been measured. A.

536.46 : 535.33.03

2410. Rotational "temperatures" of OH in diluted flames. W. R. KANE AND H. P. BROIDA. *J. chem. Phys.*, **21**, 347–54 (*Feb.*, 1953).

The effects of gaseous diluents upon the distribution of rotational energies of the electronically excited $OH(^2\Sigma^+)$ radical in flames at atmospheric pressure have been studied. He, A, N and O have been added to stoichiometric mixtures of fuel and O in amounts up to 90% of the total volume. In the reaction zones of the acetylene and methane flame diluted with He, A or N, a departure from rotational equilibrium is found which increases with increasing dilution. This effect is absent in the H flame and in flames with excess O. Vibrational and electronic nonequilibria are also indicated. These results are consistent with the hypothesis proposed in connection with low pressure studies that excited OH is formed in an exothermic reaction imparting high rotational energy to the products. Persistence of this rotational energy throughout the radiative lifetime, 10^{-6} sec, or 10^4 collisions, is indicated. A.

536.48

2411. Thermodynamics of the transition between helium I and helium II in mixtures of ^{3}He and ^{4}He. J. de Boer and C. J. Gorter. *Physica*, **18**, 565–8 (*Aug.–Sept.*, 1952).

Emphasizes that, on the assumption of the transition of a liquid mixture of He^3 and He^4 from the helium I phase into the helium II phase being a transition of the second order, pure thermodynamic reasoning, not based on any particular model, leads to predictions about discontinuities in the derivatives of the vapour-to-liquid concentration ratio r and certain other thermodynamic quantities at the transition line. A.

536.48

2412. The blocked capillary method for determining melting pressures: the melting curve of helium from 1·5° to 4°K. C. A. Swenson. *Phys. Rev.*, **89**, 538–45 (*Feb.* 1, 1953).

The blocked capillary technique has been used to check previous piston displacement values for the He melting pressure curve in the range from 1·5° to 4°K. In the course of these experiments, details of which are given, it was shown that melting pressures as given by the capillary blocking method are completely reliable, and can be very accurate. Variations of the capillary size or pressure difference across the capillary had no evident effect. The behaviour of the He melting curve in the vicinity of the upper "triple point" is discussed in some detail. An analysis of the data indicates that it is in qualitative agreement with the assumption that the λ transformation is of the second order. A.

536.48

2413. Heat conduction of the boundary layer in liquid helium II. D. White, O. D. Gonzales and H. L. Johnston. *Phys. Rev.*, **89**, 593–4 (*Feb.* 1, 1953).

In experiments on the thermal conductivity of liquid helium II, an anomalous heat conduction has been found in the vicinity of the heat source. The magnitude of this effect is given as a function of temperature and is shown to be independent of the heat flux. The effect has been ascribed to a thin layer of liquid helium in the vicinity of the energy source having a poor heat conduction. The existence of this layer is probably a consequence of the finite rate of conversion from superfluid to normal particles. A.

536.48

2414. Some points of the theory of liquid helium II. L. Goldstein. *Phys. Rev.*, **89**, 597–602 (*Feb.* 1, 1953).

Some of the limitations of the hydrodynamic model of liquid He II are studied in this paper. It is shown that the vortex or roton phase alone, without mutual interaction, undergoes a first-order phase change. The phonon-roton system does not have such a phase change if the zero-point energy or pressure is included explicitly in its formalism. In the high temperature or roton region the model has a normal state surface and does not account for the unusual equilibrium properties of liquid He II such as the anomalous expansion coefficient, the entropy increase and decrease in isothermal pressure and volume increases, respectively. The possibility of the abnormal liquid becoming normal again at very low temperatures, where the entire thermal excitation is concentrated in the phonons, is briefly discussed. A.

536.48

2415. Nuclear alignment and the entropy of liquid He^3. B. Weinstock, B. M. Abraham and D. W. Osborne. *Phys. Rev.*, **89**, 787–9 (*Feb.* 15, 1953).

By consideration of the melting pressure data it is shown that calculations implying that the nuclear spins in liquid He^3 are appreciably aligned at temperatures above 0·5°K are inconsistent with the assumption that the nuclear spins are randomly oriented in the solid. The expression $S_{liq} = R\ln 2 + 0{\cdot}344RT + 0{\cdot}013RT^3$ for the entropy of liquid He^3 (including the nuclear spin entropy) is consistent with the vapour pressure data from 1·0°K to 2·5°K and with the melting pressure data from 0·5°K to 1·5°K. A.

536.48

2416. Transport phenomena of liquid helium II in narrow slits. C. S. Hung, B. Hunt and P. Winkel. *Physica*, **18**, 629–45 (*Aug.–Sept.*, 1952).

New measurements have been carried out on the flow of matter and heat in liquid He II through slits of 1 to 5 μ widths, in order to study the equations of motion of the normal fluid and the superfluid as proposed by Gorter and Mellink (1949). It is found that, at high velocities, these equations can describe the observed phenomena very satisfactorily and values of the coefficient of the mutual friction A are calculated for different slit widths. However, below a certain value of the superfluid velocity, no friction is observed and a combined hypothesis for the two velocity ranges is given. A.

536.48

2417. On the influence of pressure on the viscosity of liquid helium I. H. H. Tjerkstra. *Physica*, **18**, 853–61 (*Nov.*, 1952).

The viscosity of liquid He^4 has been measured at pressures from 5 to 50 kg/cm^2 and temperatures between the λ-point and 4·20°K by a capillary method. A.

536.48 : 533.7

2418. Irreversible processes with application to helium II and the Knudsen effect in gases. O. K. Rice. *Phys. Rev.*, **89**, 793–9 (*Feb.* 15, 1953).

It is generally conceded that the pressure difference dp which develops in a steady state, when two portions of He II are kept at different temperatures and separated by a capillary, is given by $dp/dT = Q/TV$, where Q is the heat absorbed as volume V leaves the capillary at absolute temperature T. London gives $Q = TS$ where S is the entropy, for the case where no heat is absorbed along the capillary ($c = 0$), while Gorter gives $Q = Tx_1(\partial S/\partial x_1)$ where x_1 is the mole fraction of normal He in the He II. Gorter's equation coincides with London's, which is reasonably well confirmed experimentally, only if $\bar{S}_2$ the partial molal entropy of superfluid is zero. In this paper an analysis of the situation, including a careful discussion of the meaning of Q, is attempted, and it is shown that for $c = 0$ London's equation follows from the equation for dp/dT and the conservation of energy. The equations which are developed are quite general, and

can be applied directly to other cases, for example, the Knudsen effect in gases. They still do not permit an answer to the question concerning $\bar{S}_2$ for He, however, and for this purpose an analysis of the processes occurring within the capillary is required. It is found that if the thermodynamic properties of the fluid in the capillary are not changed from those of bulk liquid, then Gorter's equation is correct. There seems, however, to be no reason to suppose that they may not be changed, so it is concluded that no direct information regarding $\bar{S}_2$ can be obtained from experiments on the thermomechanical effect. This last statement is considered in connection with some speculations concerning the state of liquid He in a capillary and in a Rollin film. A.

536.48

2419. The propagation of pulses of first and second sound through helium II. R. B. DINGLE. *Physica*, **18**, 841–52 (*Nov.*, 1952).

Calculations are made of the change in shape of a sound pulse as it travels through an absorptive and dispersive medium. The results of the theory are discussed in connection with recent experiments on the velocity of second sound in He II, and it is concluded that the values quoted by Atkins and Osborne (1950) are probably too high. A.

536.48

2420. The velocity of second sound in various media. R. B. DINGLE. *Proc. Phys. Soc.* [*London*] *A*, **65**, 1044–50 (*Dec.*, 1952).

On the assumption that second sound can be propagated through media other than helium II, its velocity is calculated for non-ideal gases, insulators, conductors, superconductors and ferromagnets. A.

536.48

2421. Second sound velocity measurements below 1°K. D. DE KLERK, R. P. HUDSON AND J. R. PELLAM. Letter in *Phys. Rev.*, **89**, 326–7 (*Jan.* 1, 1953).

The velocities are higher than those found by Atkins and Osborne [Abstr. 1017 (1951)]. This discrepancy is attributed to the larger temperature drift in the earlier measurements, which would cause the He to be warmer than the paramagnetic salt thermometer. Below 0·4°K a further increase to 192 m/sec shows at the lowest temperature ($\sim 0{\cdot}02$°K). This rise above $\sqrt{1/3}\times$first sound velocity might be due to a shock wave phenomenon [Abstr. 2631 (1951)] or to the phonon mean free path effect [Abstr. 804 (1953)] or to dispersion. H. LONDON

536.483

2422. The liquefaction and storage of partially converted liquid hydrogen. E. R. GRILLY. *Rev. sci. Instrum.*, **24**, 1–4 (*Jan.*, 1953).

Observations on the normal storage of liquid hydrogen showed the evaporation rate and *ortho-para* conversion rate to be consistent with those expected from a non-catalysed reaction. A catalytic convertor which gives 50% *ortho* when cooled with liquid air was installed in the feed-gas line of a 25 l/hour hydrogen liquefaction plant. The decrease in storage loss is well worth the trouble of installation and operation of the convertor. A.

536.483

2423. A new type of heat interchanger for large liquefiers. J. NICOL, T. S. SMITH, C. V. HEER AND J. G. DAUNT. *Rev. sci. Instrum.*, **24**, 16–19 (*Jan.*, 1953).

Details are given of the design and performance of a heat interchanger suitable for transferring heat from a gas of high heat content per unit volume to one of low heat content per unit volume. The interchanger is suitable for use in large liquefiers, and a report is given of its performance in a helium liquefier giving 6·5 litres of liquid helium per hour. The construction is simple and involves no techniques not already available in an average laboratory workshop. A close correlation is reported between the computed and observed efficiencies and pressure drops in these interchangers. A.

536.521

2424. Simplified brightness temperature pyrometer using photoconductive cell. E. C. PYATT. Letter in *J. sci. Instrum.*, **29**, 414–15 (*Dec.*, 1952).

A modification of an instrument described previously [Abstr. 4319 (1952)] eliminating amplifiers and radiation chopping. The cell is used as before to indicate balance between the radiation from the body and that from a lamp. It is moved manually from one optical path to the other and the current through it is used as a measure of its resistance. The new instrument is much simpler but less sensitive, operating down to 300°C instead of 100°.

J. W. T. WALSH

536.55

2425. Design of an integrating thermometer. C. MAGONO. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 1–20 (*Feb.*, 1951).

Using the variation of viscosity of liquids with temperature, the author produced a series of integrating thermometers which can be used easily in the laboratory and even in the field. A.

536.633

2426. The specific heat at constant volume of compressed carbon dioxide. A. MICHELS AND J. STRIJLAND. *Physica*, **18**, 613–28 (*Aug.–Sept.*, 1952).

A description is given of an apparatus, which allows the direct measurement of the C_V of compressed gases or liquids. An adiabatic differential method is used. Two identical bombs, only one of which is filled, are heated simultaneously by an electric current. The difference in temperature rise of the two calorimeters is measured very accurately. The specific heat is determined from this difference and from the total temperature rise and the energy input. Results are published for CO_2 in the range from 20°C to 40°C at densities up to 400 Amagat units (pressures up to 200 atm.). A.

THERMODYNAMICS 536.7/.8

536.7 : 530.145

Thermodynamics of some special fields. *See Abstr.* 2185

536.7 : 530.162 : 536.42

2427. Statistical mechanics of phase change. II. Changes of higher order. A. MÜNSTER. *Z. Naturforsch.*. 7a, 613–19 (*Sept.*, 1952) *In German.*

For Pt I, see Abstr. 6187 (1951). The statistical condition for a phase transition of order r is that the $(r + 1)$th mean moments of the statistical variates become infinite. On this criterion, the singularity noted by Onsager for the two-dimensional Ising model must be classified as first order. Moments of order r of the number density can be expressed as the sum of integrals over the molecular distributions of order r. Thus, at a transition of order r, the molecular distribution functions of order greater than r become indeterminate. R. O. DAVIES

536.7 : 539.132 : 535.375.55 : 535.343.3–15

Calculated thermodynamic properties for oxalyl chloride. *See Abstr.* 2340

536.75

2428. Thermodynamic properties of carbon monoxide at temperatures between 0 and 150°C and at pressures up to 3000 atmospheres. A. MICHELS, R. J. LUNBECK AND G. J. WOLKERS. *Appl. sci. Res. A*, **3**, *No.* 4, 253–60 (1952) *In French.*

ELECTRICITY 537

THEORY . ELECTRONS 537.1

537.122

2429. The absorption in an electron/gas mixture. H. KOBER. *Ann. Phys.* [*Leipzig*] **11**, *No.* 1, 1–11 (1952) *In German.*

The kinetic theory of gases is used to calculate the influence of collision damping on the polarization of an electron/gas mixture subjected to an alternating electric field, and a first approximation to the non-linear absorption effects is obtained.

E. H. SONDHEIMER

ELECTROSTATICS . DIELECTRICS 537.2

537.21

2430. An elementary non-conservative electrical system. W. B. SMITH-WHITE. *J. Roy. Soc. New S. Wales*, **85**, *Pt I*, 15–19 (1952).

The author has previously shown that a general electrostatic system containing deformable dielectrics is non-conservative. In the system discussed the volume charge is replaced by a single point charge and the polarized region by a pair of point dipoles supposed "inductive." The strength of the dipole is proportional to the strength of field in which it lies and the proportionality constant corresponds to the dielectric constant. The coefficients depend on the dipole separation. This system is discussed by the usual "energy" method and by the mechanical action method, and is found to be non-conservative.

C. A. HOGARTH

537.21 : 537.29 : 532.77

2431. Formation of macroscopic electric charges in the interior of solutions. J. LIMA-DE-FARIA. *C.R. Acad. Sci.* [*Paris*] **235**, 1297–9 (*Nov.* 24, 1952) *In French.*

Experiments are described which indicate the formation of appreciable electric charges in the interior of solutions in regions of very strong discontinuity of the electrical field. A schematic representation of the mechanism of the acceleration of chemical reactions by an electrical field is included [see also Abstr. 4690 (1952)]. H. H. HODGSON

537.21 : 537.29 : 532.77

2432. Calculation of electric charges formed in the bulk of solutions for regions with very strong discontinuities of the electric field. J. LIMA-DE-FARIA. *C.R. Acad. Sci.* [*Paris*] **235**, 1392–4 (*Dec.* 1, 1952) *In French.*

By introducing the dielectric constant of water into the calculation of Kohlrausch, the author obtains much larger values for the charges. This result agrees with the mechanism of the acceleration of chemical reactions under the effect of an electric field.

F. LACHMAN

537.221 : 541.182.2/.3

2433. The statistics of liquid spray and dust electrification by the Hopper and Laby method. E. E. DODD. *J. appl. Phys.*, **24**, 73–80 (*Jan.*, 1953).

The electric charges created upon individual microscopic particles of an aerosol during its generation have been determined by the Hopper and Laby oil drop method. In the spraying of non-conducting liquids, the charges produced upon droplets in the diameter range 2–50 microns are found to follow a normal distribution with the average charge zero and the mean square charge proportional to droplet volume. This result favours the electrification mechanism of statistical fluctuation of electrolytic ion concentration among the droplets rather than the more prominent Lenard mechanism. The charge distribution among clean mercury droplets in the diameter range 1–6 microns sprayed from a glass sprayer is asymmetric because of contact effects at the mercury-glass interface: the average droplet charge is positive, relatively large, and increases with droplet diameter. The dependence of dispersive dust charging upon particle surface roughness is illustrated by observations made with relatively smooth microscopic glass spheres and compared with data for rough crushed quartz particles. A.

537.226

2434. The Poisson–Kelvin hypothesis and the theory of dielectrics. W. B. SMITH-WHITE. *J. Roy. Soc. New S. Wales*, **85**, *Pt III*, 82–112 (1951).

The treatment of systems involving the polarization of dielectrics from the thermodynamic viewpoint presents well-known difficulties. Given that for a dielectric body of volume v_2 and surface f_2 under the influence of a charge distribution with density ρ in a volume v, bounded by surface f, a force and a couple are observed which are distributed, a force Fdv, a couple Gdv and a force Tdf may be supposed to act on the appropriate volume and area elements. The fundamental relations are then taken to be

$F = (P\nabla)E$, $G = P \times E$ and $T = \frac{1}{2}P(E_+ - E_-)n$. P is the polarization of the dielectric, n is a unit normal drawn outward from f_2, and E_+ and E_- are electric fields just outside and just inside the dielectric. The formulae for mechanical action are then developed to account for the phenomena associated with energy in an electrical system containing dielectrics. C. A. HOGARTH

537.226 : 621.392.2

2435. On the isotropic artificial dielectric. C. SÜSSKIND. Letter in *Proc. Inst. Radio Engrs*, **40**, 1251 (*Oct.*, 1952).

The boundary effects at the surface of an artificial dielectric of the obstacle type are considered as a modification to the refractive index. A theory predicts the modification for "dielectrics" consisting of spheres of metal or quartz. Experimental data quoted are in agreement with the calculated values of effective dielectric constant. W. T. BLACKBAND

537.226.2

2436. On the theory of dielectric relaxation in dipole liquids. A. BUDÓ. *Acta phys. Hungar.*, **2**, *No.* 1, 13–29 (1952) *In German.*

In order to investigate the influence of the surroundings, taking account of form and structure of the individual molecules, the Debye–Ramm theory has been extended. It is applied to the case of ellipsoidal molecules as well as of molecules with 2 freely rotating dipole groups with a common axis. The distribution of relaxation times for small and large E/kT was determined. J. JACOBS

537.226.2

2437. Dielectric constant of argon at 9700 Mc. C. M. ZIEMAN. Letter in *J. appl. Phys.*, **24**, 110 (*Jan.*, 1953).

The results of 33 measurements, using a previously-described method [Abstr. 3565 (1952)] give when reduced to S.T.P.: $(\varepsilon - 1)\,10^4 = 5{\cdot}549 \pm 0{\cdot}019$. F. F. ROBERTS

537.226.2

2438. Electric polarizability of polar ions. K. J. MYSELS. *J. chem. Phys.*, **21**, 201–5 (*Feb.*, 1953).

Polar ions are compared with well-known uncharged dipoles with respect to their polarizability and the contribution to the dielectric constant of their solutions. It is shown that (1) hydrodynamic forces exerted by the solvent on the solvated ion have to be taken into account in any kinetic discussion of dielectric behaviour. (2) For ions having a symmetrical shape the polarizability is the same as that of an uncharged dipole obtained by adding, at the centre of symmetry of the ion, a neutralizing charge. (3) The same effective dipole enters into the thermodynamic considerations of unsymmetrical ions. (4) The dipole analogy may be extended to the general case, leading to a rigorous but implicit expression. (5) As a first approximation, the polarizability of an ion is an indication of its dissymmetry. A.

537.228.1 : 534.121.1 : 621.396.611.21

2439. Thickness vibrations of piezoelectric crystal plates. R. BECHMANN. *Arch. elekt. Übertragung*, **6**, 361–8 (*Sept.*, 1952) *In German.*

After a consideration of the influence of the piezoelectric secondary effect on the mechanical properties of plates, a complete derivation of the electromechanical vibration system for an infinite plate is given. For plates of finite size, the assumption of uniform amplitude distribution is invalid. The influence of an irregular amplitude distribution in the plane of the plate on the electro-mechanical properties of the plate is discussed with special reference to its practical application. H. J. H. STARKS

537.228.1 : 534.121.1 : 621.396.611.21

2440. Piezoelectric oscillations of quartz plates at even and half-odd harmonics. S. PARTHASARATHY, M. PANCHOLY AND A. F. CHHAPGAR. Letter in *Nature* [*London*] **171**, 216–18 (*Jan.* 31, 1953).

Several workers have reported that a piezoelectric quartz plate can be excited at even and half-odd harmonics, although even harmonics are not permissible by theory. The discrepancy has been accounted for by twinning or other defect in the quartz, inhomogeneous electric fields, uneven plating or feedback to the oscillator. Experiments are described in which special precautions were taken to minimize these effects. The amplitude of the oscillations as indicated by the intensity of the diffraction lines is given graphically, and it is concluded that a quartz plate has preferred modes of oscillation at the even and half-odd multiples of its fundamental frequency in addition to the more strongly excited odd harmonics. H. J. H. STARKS

ELECTRIC CONDUCTION . CURRENTS 537.3

537.311.23 : 621.3.014.1

2441. Current flow in cylinders. W. R. SMYTHE. *J. appl. Phys.*, **24**, 70–3 (*Jan.*, 1953).

The mixed boundary value problem arising from the flow of current into a right circular cylinder of radius a through a perfectly conducting coaxial disk electrode at one end is solved approximately. The boundary conditions are met rigorously except that the electrode is not quite plane. A solution valid for all values of the disk radius is given for which in the worst case the deviation from flatness is nearly $0{\cdot}01a$. More exact solutions are worked out for disk radii $\frac{1}{4}a$, $\frac{1}{2}a$ and $\frac{3}{4}a$ and the first forty coefficients in the Bessel function series for the potential in the cylinder are tabulated. A cylinder whose diameter is eight times its length is also treated for disk radii $\frac{1}{4}a$ and $\frac{1}{2}a$ and the first forty coefficients in the potential series are tabulated. The probable errors in the resistance formulae derived from these solutions are given. A.

537.311.31

2442. Resistance anomalies of a highly permeable nickel–iron–molybdenum alloy. F. ASSMUS AND F. PFEIFFER. *Entwicklungsber. Siemens & Halske*, **15**, 75–80 (*May*, 1952). [Reprint from *Z. Metallk.*, **42** (*Oct.*, 1951)] *In German.*

Anomalies are described in the permeability and resistance at cold and hot tempers of an alloy containing 79·05% Ni, 5% Mo, 0·42% Mn and the rest Fe. Nine curves are included to show the time

and temperature effects on resistance, the energy requirements, and a comparison with known resistance anomalies in homogeneous mixed crystals. 16 references. H. H. HODGSON

537.311.31

2443. The electrical resistances of alloys of a noble metal and a transition metal. A. N. GERRITSEN AND J. O. LINDE. *Physica*, **18** 877–90 (*Nov.*, 1952).

The electrical resistances of wires of Au and Cu, containing small amounts of Mn and Cr have been determined at low temperatures. Apart from quantitative differences, analogous anomalies have been found as in the case of dilute Ag–Mn alloys, which, as published before, have a minimum and at a lower temperature a maximum in the resistance temperature curve. An analysis of the change of the resistivity per atom per cent solute as a function of the temperature underlines the similarity among the binary alloys with Mn and Cr as a second component in comparison with Zn as a solute. This seems to indicate that the anomalous behaviour is characteristic for a contamination of a noble metal by a transition metal. A.

537.311.31 : 537.311.62

2444. The mean free path of conduction electrons in bismuth. A. B. PIPPARD AND R. G. CHAMBERS. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 955–6 (*Nov.*, 1952).

This was estimated from measurements on the anomalous skin effect, and was found to lie between 2 and 4 μ at room temperature. E. H. SONDHEIMER

537.311.32

2445. Contributions on the electrical conduction of coloured and uncoloured alkali halide crystals. P. TOMKA. *Acta phys. Hungar.*, **2**, *No.* 3, 209–22 (1952) *In German.*

537.311.33

2446. Bound electronic states in solids, resulting from a "potential hill." J. J. O'DWYER. *Rep. Brit. Elect. Res. Assoc., Ref. L/T*253, 5 *pp* (1951).

Slater has recently given a very general demonstration [Abstr. 3157 (1949)] that there should be electronic energy levels associated with "potential hills" (i.e. defects corresponding to an additional negative charge) in crystalline solids. This paper discusses these energy levels more exactly, and some calculations are done for various types of solid. The method used is that developed by Simpson (1949) in connection with the similar problem concerning "potential holes." Only the two simplest types of "potential hill" are discussed, viz. an interstitial negative ion and a vacant positive ion lattice position. It is found that the energy level is distinct from a conduction band only for non-polar or for very slightly polar solids, and moreover that the energy separation from the conduction band is so small for most solids, that it is not significant except at very low temperatures in which case we should expect that there would not be an appreciable number of lattice defects. A.

537.311.33

2447. The semiconducting properties of cuprous oxide. J. S. ANDERSON AND N. N. GREENWOOD. *Proc. Roy. Soc.*, *A*, **215**, 353–70 (*Dec.* 5, 1952).

A procedure has been developed for preparing reproducible specimens of cuprous oxide at the oxygen-poor limit of its composition range. The electrical conductivity and thermoelectric power of such specimens were measured simultaneously, and related to temperature within the range 20 to 1030°C. The conductivity-temperature curve consists of two limbs, the slopes of which correspond to activation energies of 0·300 and 1·04 eV respectively. The relation between thermoelectric power and temperature also falls into two segments, the temperature of discontinuity agreeing closely with the break in the conductivity curve. Below 355°C the thermoelectric power is quite independent of temperature and has a value 1·64 mV deg^{-1}. Above 355°C the thermoelectric power decreases with rise in temperature; its sign does not change, but remains characteristic of a positive-hole conductor up to the highest temperatures investigated. The effect of oxygenating cuprous oxide of limiting composition has also been studied. With an ambient pressure of 9 mm oxygen the activation energies for conduction decreased to 0·238 and 0·877 eV respectively, and the constant value of the thermoelectric power dropped to 1·0 mV deg^{-1}. The theoretical implications of these results are discussed, and it is concluded that the existing semiconductor models provide no satisfactory explanation of a temperature-independent thermoelectric power in a region where the number of current carriers is strongly dependent on temperature. A.

537.311.33

2448. Noise measurements on thin lead sulphide photolayers. F. ECKART. *Ann. Phys.* [*Leipzig*] **11**, *No.* 2–3, 166–8 (1952) *In German.*

Measurements are made on chemically prepared and oxygen-treated PbS layers as photoconductors. The absolute value of noise current is proportional to the cell current and is independent of the origin of the electrons involved, i.e. whether due to photoelectric or thermal excitation. The dark current and mean noise are proportional to the field strength. The mean life-time of the charge carriers is obtained from mobility values calculated from Hall coefficient measurements. G. F. J. GARLICK

537.311.33

2449. Transition probability for photoelectric emission from semiconductors. H. B. HUNTINGTON AND L. APKER. *Phys. Rev.*, **89**, 352–6 (*Jan.* 15, 1953).

An adaptation of Makinson's theory of photoelectric emission from metals is used to treat simple one- and three-dimensional semi-conductor models. The probability of excitation from a state of initial energy ε lying near ε_0, the top of an occupied band, is found proportional to $\varepsilon_0 - \varepsilon$. Thus, the transition probability vanishes at the top of the band. For a density of states having the normal form, $n \sim (\varepsilon_0 - \varepsilon)^{\frac{1}{2}}$ the energy distribution of the emitted electrons contains a factor $(\varepsilon_0 - \varepsilon)^{\frac{1}{2}}$ and is thus concave upward near the band edge. For certain simple surfaces, the photoelectric threshold may be high because transitions requiring low energy are forbidden. It is pointed out that this feature is an idealization probably not found for real surfaces having the usual inevitable irregularities. In a qualitative discussion, more realistic cases are mentioned. It is suggested that the results retain the form derived above, although the

high threshold energy disappears. An energy distribution proportional to $(\varepsilon_0 - \varepsilon)^{\frac{3}{2}}$ near the band edge is in good agreement with previous experimental results on Te and other monatomic semiconductors. With the graphical methods of analysis previously applied to data on these materials, the point of view taken above permits more definite location of the edges of occupied bands. Improved estimates of upper limits to the density of occupied surface levels are then possible. A.

537.311.33

2450. Extension of Makinson's theory of photoelectric emission to a periodic potential. H. B. HUNTINGTON. *Phys. Rev.*, **84**, 357–8 (*Jan.* 15, 1953).

The results of Makinson's treatment of the transition probability for photoelectric emission for a free-electron model has been extended to Bloch wave functions in a periodic field. The particular application of these results to the case of electrons at the top of a filled band has been developed, thereby filling in some of the details of the paper reported in the preceding abstract. A.

537.311.33

2451. Thermal treatment of silicon rectifiers. L. ESAKI. *Phys. Rev.*, **89**, 398–9 (*Jan.* 15, 1953).

The effect of thermal treatment on Si point contact rectifiers over the temperature range between 900°C and 1400°C, both in high vacuum and in an O atmosphere below about 0·1 mm Hg, has been investigated by means of heating a Si specimen directly. During the treatment above 1250°C in vacuum, the rectification is changed remarkably and is finally lost. It is recovered by successive heat treatment in O. Both the creation of thermal donors or acceptors and the absorbed O may be regarded as causes of these phenomena. The contact area calculated from the ohmic resistance at the non-rectifying contact is the order of 10^{-6} cm². A.

537.311.33

2452. Interpretation of α-values in *p–n* junction transistors. F. S. GOUCHER AND M. B. PRINCE. *Phys. Rev.*, **89**, 651–3 (*Feb.* 1, 1953).

By the measurement of five parameters in several *p–n* junction transistors, viz. the conductivities and diffusion lengths of minority carriers in the emitter and base regions and the widths of the base regions, the current amplification factor α of the transistors has been computed from theory. Previous to this investigation two of the parameters associated with the thin *p*-layer had not been measured. The quantity α also was obtained independently by two alternate methods: (1) by measuring the collector-emitter current characteristic, and (2) by measuring the apparent quantum efficiency of the transistor as a two-electrode photocell with a floating base. The three determined values of α for each sample agree within the experimental error. A.

537.311.33

2453. Titanium dioxide rectifiers. R. G. BRECKENRIDGE AND W. R. HOSLER. *J. Res. Nat. Bur. Stand.*, **49**, 65–72 (*Aug.*, 1952).

A new type of metal rectifier is described which utilizes a film of semiconducting TiO_2 produced on Ti metal. These rectifiers, which have been prepared either by a two-step process involving a heating of the metal in oxygen followed by a reduction of the oxide in hydrogen or by a single heating of the metal in water vapour, are shown to have properties comparing favourably with existing types, particularly for high-temperature applications. The properties of the units in regard to the nature of the counter-electrode, and relation to theories of rectification are discussed. A.

537.311.33 : 621.3.014.1 : 621.314.7

2454. Large current amplifications in filamentary transistors. W. VAN ROOSBROEK. Letter in *J. appl. Phys.*, **23**, 1411–12 (*Dec.*, 1952).

It is shown theoretically that in principle large values of current gain could be obtained by the use of filaments of extremely small dimensions and for which the surface recombination velocity is negligibly small. The longitudinal electric fields required for the appropriate conductivity modulation are found to be very high for specimens of this type. C. A. HOGARTH

537.311.33 : 621.314.63

2455. Reverse characteristics of high inverse voltage point contact germanium rectifiers. J. H. SIMPSON AND H. L. ARMSTRONG. *J. appl. Phys.*, **24**, 25–34 (*Jan.*, 1953).

A theory is developed, which takes account of the radial symmetry of the point contact and the presence of positive holes in the "inversion region" of the semiconductor. The field at the metal is found to consist of three components. The first varies inversely with the radius of the contact and directly with the applied voltage for larger voltages. The second is produced by the impurity centres and varies approximately as the cube root of the voltage. The third is produced by the positive holes in the inversion region and is approximately constant. This last component lowers the effective barrier height for rectifiers made of very pure material. The first is the more important of the variable components and is responsible for increases in current resulting from image force and tunnel effect at high voltages. In the former case the logarithm of the current varies as $V^{\frac{1}{2}}$ and in the latter as V^2 approximately. Current-voltage curves of the predicted forms have been found experimentally using short rectangular pulses varying in length from 2 to 10 μsec to minimize thermal effect. Where possible, barrier heights are determined by measurements over a range of temperatures and detailed numerical comparisons of theoretical and experimental data are made. The two sets of data are in remarkably good agreement thus implying that the theoretical picture is essentially correct. A.

537.311.33 : 621.314.7

2456. Transistor action in lead telluride. C. A. HOGARTH. *Proc. Phys. Soc.* [*London*] *B*, **65**, 958–63 (*Dec.*, 1952).

Transistor action has been observed in single crystals of lead telluride, examined at 90°K. Properties of the units are described and it is found that values of current gain > 1 may be observed. A.

537.311.35

2457. Studies of electrical conductivity in liquid hydrocarbons. J. C. CARDOSO. *Rev. Chim. pura apl.* (*Ser.* 4) **3**, 51–63 (*Jan.–Dec.*, 1952) *In Portuguese.*

D.C. conductivity measurements on *m*-xylene,

benzene and toluene are described and curves are presented showing: (i) a short range of constant current in the 2–20 V region of the current/voltage characteristic at room temperature; (ii) a faster than linear increase of current over the 200–1800 V range; (iii) an increase of current with temperature for benzene at 8 V; (iv) a decrease of current with increase of temperature for benzene at 1560 V; and (v) some absorption effects for benzene at 1–4 V with time constants of a few minutes. The results are discussed with reference to those of Gemant (1933). F. F. ROBERTS

537.311.62

2458. The anomalous skin effect. R. G. CHAMBERS. *Proc. Roy. Soc. A*, **215**, 481–97 (*Dec.* 22, 1952).

The anomalous skin effect arises in good conductors at low temperatures and high frequencies when the electronic mean free path becomes comparable with or greater than the classically calculated skin depth. Measurements have been made on a number of metals at frequencies of 1200 and 3600 Mc/s, and the form of variation of r.f. surface conductance with d.c. conductivity agrees well with that predicted theoretically by Reuter and Sondheimer (1948), assuming that the electrons are scattered diffusely when they hit the surface of the metal. From the results, estimates are made of the effective value of σ/l, the ratio of d.c. conductivity to mean free path, and hence of the free surface area of the occupied region of k-space. The estimate for Cu agrees well with that expected theoretically; those for Ag and Au are rather lower than the theoretical values. For the other metals investigated, Sn, Cd, Pb and Al, no theoretical estimates are available. The results are very sensitive to the presence of surface imperfections; the effect of these is discussed. A.

537.312.5

2459. Investigation of the Brown effect in hexagonal selenium crystals. H. FRANK. *Slaboproudy Obzor*, **13**, 194–202 (*Sept.*, 1952) *In Czech.*

Monocrystals of hexagonal Se were produced by vacuum distillation. Great care was taken to reproduce as accurately as possible the conditions which existed in the experiments of Brown (1915). It was found that the Brown effect, i.e. the photoelectric phenomena caused by illumination of the Se crystal outside the interelectrode space, is due to the diffusion of i.r. light inside the crystal. The same phenomenon was also observed in the case of other semiconductors which are transparent to i.r. radiation, e.g. needle-like crystals of natural antimonite (Sb_2S_3). On testing two composite monocrystals the Brown effect was found to extend beyond the boundary of the first crystal, but is weakened to a quarter of the original intensity on passing from one crystal to the other. This is the main reason why the Brown effect was not observed in grey polycrystalline Se. By measuring the spectral differences between the normal photoelectric effect and the Brown effect it was found that the grey modification of hexagonal Se is transparent to i.r. radiation above 0·8 microns. E. GROS

537.312.5

2460. Photoemission from cesium and rubidium tellurides. E. TAFT AND L. APKER. *J. Opt. Soc. Amer.*, **43**, 81–3 (*Feb.*, 1953).

Photons of energy $h\nu > 3{\cdot}5$ eV eject external photoelectrons from the valence bands of the semiconductors Cs_2Te and Rb_2Te with a quantum efficiency as high as 30%. Fundamental optical absorption sets in roughly at this same point. These materials are similar to Cs_3Sb, except that they have forbidden energy zones almost twice as wide. Consistent with this, energy distributions show no evidence for electron-electron scattering up to $h\nu = 6{\cdot}7$ eV. These substances are interesting for ultraviolet photometry. A.

537.312.5 : 537.533.74

2461. Electron scattering and the photoemission from cesium antimonide. L. APKER, E. TAFT AND J. DICKEY. *J. Opt. Soc. Amer.*, **43**, 78–80 (*Feb.*, 1953).

Photoelectron energy distributions for Cs_3Sb change radically in character when $h\nu$ exceeds 4 eV. This is attributed to scattering of excited electrons by valence electrons—a process not possible for $h\nu < 4$ eV. The results substantiate the zone structure proposed for Cs_3Sb by J. A. Burton. A.

537.312.5 : 548.7

2462. Infrared photoconductivity due to neutral impurities in silicon. E. BURSTEIN, J. J. OBERLY AND J. W. DAVISSON. Letter in *Phys. Rev.*, **89**, 331 (*Jan.* 1, 1953).

Photoconductivity due to impurities in silicon crystals is observed out to 38 μ at liquid He temperatures in a purely n-type crystal with 4×10^{15} charge carriers/cm^3 at room temperature and the response time is $<10^{-4}$ sec. The optical activation energy for the donor centres appears to be 0·04 eV. G. F. J. GARLICK

537.312.6 : 537.32 : 536.21

2463. Thermal conductivity, electrical resistivity, and thermoelectric power of graphite. W. W. TYLER AND A. C. WILSON, JR. *Phys. Rev.*, **89**, 870–5 (*Feb.* 15, 1953).

The thermal conductivity, electrical resistivity and thermoelectric power have been measured in the temperature range from 20°K to 300°K for samples of artificial extruded graphite, natural moulded graphite, and lampblack graphite. Experimental results are presented and discussed briefly in relation to theory. Due to the very large Wiedemann–Franz ratio and its dependence on temperature and type of graphite, thermal conductivity in graphite is attributed primarily to lattice waves. Scattering of lattice waves from crystallite boundaries limits the conductivity through most of the temperature range investigated. Interpretation of the data in terms of the simple Debye equation for lattice conductivity permits rough estimates of effective crystallite size. At low temperatures, the dependence of conductivity on temperature is more rapid than the dependence of heat capacity, in disagreement with the Debye equation. The temperature dependence of electrical resistivity is interpreted using a modified Wallace zone theory which permits the Fermi level to differ in position from the zone boundary, owing to an excess or deficit of electrons. Scattering of electrons in the temperature range of interest is attributed to crystallite boundaries or atomic imperfections and assumed temperature independent. The temperature dependence of the Fermi level which gives the best fit

to experimental data is not in agreement with theoretical predictions. A.

537.312.62

2464. Coulomb interaction and the Meissner–Ochsenfeld effect. M. R. SCHAFROTH. *Nuovo Cimento*, **9**, 291–303 (*March*, 1952).

By application of previously developed methods [Abstr. 3599 (1952)] it is shown that the Coulomb force in a gas of free charged particles does not produce a Meissner–Ochsenfeld effect as long as the perturbation series with respect to the Coulomb interaction converges. A.

537.312.62

2465. A few remarks on the two-fluid model for superconductors. P. L. BENDER AND C. J. GORTER. *Physica*, **18**, 597–604 (*Aug.–Sept.*, 1952).

The Heisenberg–Koppe version of the two-fluid model for superconductors is compared with the original suggestion of Gorter and Casimir. The differences between the two versions are notable only at relatively low temperatures. The available data give a few indications in favour of the Heisenberg–Koppe version. A.

537.312.62

2466. Forces acting on superconductors in magnetic fields. I. ŠIMON. *J. appl. Phys.*, **24**, 19–24 (*Jan.*, 1952).

The forces acting on a superconducting body in a magnetic field may be obtained by analogy with hydrodynamics, considering the similarity of the force field around a perfect diamagnetic with the flow field of an ideal liquid past an impermeable body of the same shape. The translation is provided by replacing $\frac{1}{2}\rho v^2$ by $(\frac{1}{8}\pi)\mu H^2$. As a practical application of the repulsive forces acting on superconductors in a diverging magnetic field, design of two types of magnetic supports for a sphere is described. In the coil-type support, two coils with opposed currents are necessary to provide stable equilibrium. Similarly, the permanent-magnet-type support requires two transversely magnetized rings with opposed polarity. The dissipation of energy in a rotating sphere by eddy currents and by viscous drag of the surrounding gas was studied. The non-existence of any torque on a free-floating, superconducting sphere in a rotating, transverse field indicates absence of interaction between the superconducting electrons and the metallic lattice. A.

537.312.62

2467. Superconducting properties of cobalt disilicide. B. T. MATTHIAS AND J. K. HULM. *Phys. Rev.*, **89**, 439–41 (*Jan.* 15, 1953).

A solid rod of cobalt disilicide was found to have a superconducting transition temperature close to 1·4°K, a critical field gradient of 146 gauss per degree at the transition point, an ice-point resistivity of 16·5 $\mu\Omega$ cm and a residual resistivity of about 16% of the ice-point value. A.

537.312.62

2468. An anomalous critical current effect in superconducting NbN. F. C. HALEY AND D. H. ANDREWS. *Phys. Rev.*, **89**, 821–3 (*Feb.* 15, 1953).

Observations have been made of thirty transitions from the normal to the superconducting state occurring in four samples of NbN over a range of current from 0·01 mA to 10 mA. The samples were made from 5 and 10 mil diameter wire and from ¼ to 1 mil thick sheets. For $H_I > 100$ oersted evidence was found for the usual parabolic relation between T and H_I, the field produced at the surface of the wire by currents just sufficient to make $R = 0{\cdot}5\ R_n$; but for $H_I < 100$ oersted the curve tailed off to higher values of temperature, approaching the axis for $H_I = 0$ tangentially several tenths of a degree above the value of T_0 where it is normally assumed to intersect the axis as a straight line. This is further evidence in support of Mendelssohn's suggestion of a sponge-like structure for superconducting alloys. A.

537.312.9 : 537.32

2469. The influence of elastic shear strains on the conductivity and thermo-electric force of cubic metals. J. SMIT. *Physica*, **18**, 587–96 (*Aug.–Sept.*, 1952).

Elastic shear strains cause a change in the shape of the Fermi surface of metals. The influence that such a change has upon the electrical conductivity and the thermo e.m.f. has been calculated for monovalent f.c.c. metals, and the results of it have been compared with the experimental values for Cu, Ag and Au. The conclusion can be drawn that the Fermi surface of Au touches the Brillouin zone boundary, whereas that of Cu does not, whilst Ag is an intermediate case. The theoretical results account also qualitatively for the experimental values of the trivalent Al. A.

537.364

2470. Streaming potentials across glass capillaries for sinusoidal pressure. R. G. PACKARD. *J. chem. Phys.*, **21**, 303–7 (*Feb.*, 1953).

A mathematical expression for the streaming potentials developed across capillaries for sinusoidal pressure variations is derived. Glass capillaries are used to check the theory experimentally, and good agreement is obtained for all samples tested. A.

ELECTRIC DISCHARGES 537.52

537.523.5 : 536.5

2471. The temperature of electric arcs. J. LABOURET AND G. LACROIX. *Rev. gén. Elect.*, **51**, 581–6 (*Dec.*, 1952) *In French.*

The paper first gives a brief review of some of Smit's work, then an account of an experimental arrangement for recording photoelectrically the emission spectrum of arcs. From observations of the black-body spectrum emitted by carbon particles in an arc in air at 15–45 A, temperatures of 5400–6100°K were found. For hydrogen arcs (10–20 A) comparison of the spectra with a series of stellar spectra indicated an excitation temperature of 7500°K, in agreement with Smit. J. D. CRAGGS

537.523.5 : 621.3.014.31

2472. Electrode phenomena in transient arcs. J. M. SOMERVILLE, W. R. BLEVIN AND N. H. FLETCHER. *Proc. Phys. Soc.* [*London*] *B*, **65**, 963–70 (*Dec.*, 1952).

High-current, short-duration arcs between various metals in air have been studied by means of a Kerr cell

camera and by observation of the marks left on the electrodes. Growth of these marks with arc duration is discussed and shown to be due to heat conduction in the case of the anode marks and to motion of the emitting areas in the case of cathode marks. Cathode spot temperatures are frequently too low for thermionic emission even on metals of high boiling point. At very high rates of current rise both anode and cathode marks are multiple. A.

537.525.2 : 537.533

Field emission: large current densities, space charge. *See Abstr.* 2479

537.525.8

2473. Determination of electron density and collision frequency in a gaseous discharge by microwave propagation measurements. L. GOLDSTEIN, M. A. LAMPERT AND R. H. GEIGER. *Elect. Commun.*, **29**, 243–5 (*Sept.*, 1952).

From measurements of absorption and phase shift of microwaves passing through a discharge, several wavelengths long, in a waveguide, the electron densities and collision frequencies may be deduced if at least two frequencies are used. Results are quoted for argon discharges at 0·5 and 2 mm Hg pressure and for 2–16 mA current. The electron densities, nearly the same at 8500 and 12 000 Mc/s, varied from 1 to 15×10^9/ml. J. D. CRAGGS

537.529 : 537.533

Internal field emission from localized defects in insulating crystals. *See Abstr.* 2478

X-RAYS 537.531

537.531

2474. Spectral energy distribution in X-ray beam as a function of wavelength. R. D. SPECHT AND M. A. GREENFIELD. Letter in *J. Opt. Soc. Amer.*, **43**, 60 (*Jan.*, 1953).

A justification of the method used in an earlier paper [Abstr. 2729 (1952)] of obtaining the spectral energy distribution as a function of the wavelength.

C. TURNER

537.531 : 535.343

2475. The M_{IV} and M_V absorption edges of ^{59}Pr, ^{60}Nd, ^{62}Sm and ^{63}Eu. H. F. ZANDY. *Proc. Phys. Soc.* [*London*] *A*, **65**, 1015–22 (*Dec.*, 1952).

Investigations on the M_{IV} and M_V absorption edges of four of the "light" rare earth elements are described, using a bent crystal focusing spectrometer. In particular, close attention has been paid to the occurrence of fine structure ("white lines") on the long wavelength side of the edge. Such white lines are found at both edges for Pr^{59}, Nd^{60} and Sm^{62}, but for Eu^{63}, while a white line is found at the M_V edge, it is absent or very weak at the M_{IV} edge. A.

537.531 : 535.822.9

2476. The scanning X-ray microscope. H. H. PATTEE, JR. Letter in *J. Opt. Soc. Amer.*, **43**, 61–2 (*Jan.*, 1953).

It is proposed that the scanning techniques recently used in light microscopy [Abstr. 5063 (1952)] be applied to X-ray microscopy in order to improve the present limit of resolution. W. BARDSLEY

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

2477. Field emission from nickel surfaces. R. GOMER. *J. chem. Phys.*, **21**, 293–303 (*Feb.*, 1953).

An account of field emission experiments on clean and contaminated nickel surfaces is presented. It is concluded that the equilibrium shapes of Ni single crystals are close to spheroidal with flat regions at low index directions. Evidence for the formation of surface phases of carbon, silicon and oxygen on Ni is presented. A method for studying the diffusion of Si in Ni is described. Chemisorption of O_2 on Ni is briefly described. A method for studying grain boundary migration is given. A.

537.533 : 537.529

2478. Internal field emission from localized defects in insulating crystals. W. FRANZ. *Ann. Phys.* [*Leipzig*], **11**, *No.* 1, 17–24 (1952) *In German.*

The probability of emission of a trapped electron from a defect by tunnel effect has been considered. The anisotropy of the crystal was neglected and the defect represented by a spherical potential well. The results indicate that field emission may be expected if the binding energy of the trapped electrons is less than 0·5 V. P. T. LANDSBERG

537.533 : 537.525.2

2479. Field emission: large current densities, space charge, and the vacuum arc. W. P. DYKE AND J. K. TROLAN. *Phys. Rev.*, **89**, 799–808 (*Feb.* 15, 1953).

Field emission was obtained from a single crystal W emitter under conditions of very high vacuum and clean surfaces. The geometry of the emitter was determined by electron microscopy permitting accurate calculation of both the surface electric field and an average current density. The use of pulse electronic techniques extended the observations to the upper limit of the current densities for which the normal field emission was stable. Above this limit an explosive vacuum arc occurred between electrodes. From these experiments the following conclusions were drawn. (1) The wave mechanical, image-force-corrected theory quantitatively predicted the observed average current density up to that density for which space charge dominated the emission. (2) Space charge was effective at a current density of the order of 10^7 amperes/cm^2, where a marked deviation occurred from the usual current-voltage relationship. Space charge effects permitted the simultaneous operation of multiple emitting areas of differing geometries. (3) At a still higher critical current density in the range 10^7 to 10^8 amperes/cm^2, a field-emission-initiated vacuum arc occurred between electrodes, resulting in a change of emitter geometry. Current density was the dominant criterion for the initiation of the vacuum arc. A.

537.533 : 621.384.611

2480. On the optimum adjustments of the electron cyclotron. C. SCHMELZER. *Z. Naturforsch.*, **7a**, 808–17 (*Dec.*, 1952) *In German.*

The Veksler–Schwinger type of electron accelerator as realized by W. J. Henderson *et al.* [Abstr. 4016 (1949)] is discussed and the conditions for greatest acceleration with given magnetic field dimensions

derived. The phase-stability and energy distribution of the beam are investigated graphically. Resonance acceleration is possible for, at most, about $\frac{1}{12}$ period. Transit-time effects can much reduce the extent of the stable domains but can be overcome by careful adjustment or by use of particular acceleration systems. A. H. W. BECK (R.)

537.533.7

2481. The self-charge broadening of a focused electron beam. H. GRÜMM. *Ann. Phys.* [*Leipzig*] **11**, *No.* 2–3, 131–44 (1952) *In German.*

Wave mechanics is used to obtain the intensity distribution and simple formulae for the upper bounding values of the beam broadening, shift of the picture plane, shift of the Fraunhofer plane, etc.

A. H. W. BECK

537.533.72

2482. Study of an electronic [magnetic] lens with the WKB method. C. MUSCIA. *R.C. Accad. Naz. Lincei*, **12**, 575–82 (*May*, 1952) *In Italian.*

For a field of the form $H_z = H_0[1 + (Z/a)^2]^{-3/2}$ the differential equation for the electronic path is a Mathieu equation, which can be dealt with by standard quantum-mechanical methods. The WKB approximate solution is compared with the exact one (obtained numerically). Agreement is better for high values of $H_0^2a^2/V$ (V = accelerating potential).

L. PINCHERLE

537.533.72

2483. Calculation of spherical aberration for the electrostatic electron lens. D. W. SHIPLEY. *Sylvania Technol.*, **5**, 87–93 (*Oct.*, 1952).

Integral expressions for the coefficient of spherical aberration of an electrostatic electron lens contain the axial potential distribution of the lens and a particular solution of the paraxial-ray equation. The axial potential distribution is determined by means of the electrolytic tank; the particular paraxial-ray path is obtained by a method of successive approximations. The coefficient of spherical aberration of the lens is calculated by numerical integration. Finally the result is compared with a value which was measured experimentally. A.

537.533.72

2484. Electron optical image of an electron beam. L. MAYER. Letter in *J. appl. Phys.*, **24**, 105–6 (*Jan.*, 1953).

It has been found possible to photograph the image of a fast electron beam when it is illuminated by a beam of slower electrons. G. D. SIMS

537.533.72 : 539.154

2485. A new determination of $h/\sqrt{(em_0)}$ by electron diffraction. T. B. RYMER AND K. H. R. WRIGHT. *Proc. Roy. Soc. A*, **215**, 550–64 (*Dec.* 22, 1952).

The wavelength of electrons of energy 40 to 60 keV has been determined from the diffraction patterns of transmission specimens of alkali halides and metals. The accelerating potential was measured by a special potentiometer and hence the quantity $h/\sqrt{(em_0)}$ was derived. The results using specimens of NaCl, KCl, CsI and Al were mutually consistent and their mean value was $h/\sqrt{(em_0)} = (1{\cdot}00156 \pm 0{\cdot}00010) \times 10^{-8}$ (e in e.s.u.). Specimens of Au and LiF gave anomalous results. A.

537.533.72

2486. Interpretation of the structure of electronic images. R. BERNARD AND E. PERNOUX. *C.R. Acad. Sci.* [*Paris*] **235**, 1488–90 (*Dec.* 10, 1952) *In French.*

The resultant image of a crystalline structure obtained with an electron microscope comprises the sharp image which results from those electrons which travel through the object with little deviation from their initial direction, together with a diffuse diffraction image. If the objective is defocused the latter image separates from the former enabling additional information to be deduced about the domain structure of the object. G. D. SIMS

537.533.72

2487. Electron microscopy by reflection. C. FERT AND R. SAPORTE. *C.R. Acad. Sci.* [*Paris*] **235**, 1490–2 (*Dec.* 10, 1952) *In French.*

Briefly describes a microscope in which the electron beam is reflected at a large angle of incidence from an object which is inclined at a small angle to the axis of the system. A resolving power of 250 Å has been obtained. G. D. SIMS

537.533.72

2488. Colour in electron microscopy. G. E. DONOVAN AND E. STAFFORD. Letter in *Nature* [*London*] **170**, 1126 (*Dec.* 27, 1952).

Micrographs of the same specimen taken with different accelerating voltages show up different detail. To exhibit all such detail simultaneously, micrographs taken at different voltages were optically superimposed, using different coloured light for each accelerating voltage. R. S. PEASE

537.533.72 : 539.27

2489. Practical electron microscopy. V. E. COSSLETT. *London, Butterworth Scientific Publications; New York, Academic Press* (1951) 299 + xiii *pp. Figs* 147.

Review in *Rev. sci. Instrum.*, **24**, 57 (*Jan.*, 1953).

537.533.72

2490. On the design of a 15 MeV β-ray spectrometer. R. L. GRAHAM AND O. KLEMPERER. *Proc. Phys. Soc.* [*London*] *B*, **65**, 921–34 (*Dec.*, 1952).

The design of a lens spectrometer with respect to economy in power consumption and copper weight, resolving and collecting power has been studied by small scale experiments. The construction and performance of a large β-ray spectrometer is described which focuses 15 MeV electrons when its coil is energised by 50 A at 360 V. The coil is cooled by a flow of 12 gallons of water per minute. Maximum resolution and collecting power of the spectrometer are 0·8% and 0·6% respectively. The influences of spherical aberration, source and window size on the resolution of the thick lens spectrometer are discussed. A.

537.533.72 : 539.163.2

2491. A description of a large double-focusing beta spectrometer and its application to a study of the decay of In^{114}. M. W. JOHNS, H. WATERMAN, D. MACASKILL AND C. D. COX. *Canad. J. Phys.*, **31**, 225–34 (*Feb.*, 1953).

The design and performance of a Siegbahn type

double-focusing β spectrometer of radius of curvature 50 cm are described. It has a resolution of 0·3% with a transmission of a few tenths of a per cent. A study of the decay of In^{114} has revealed γ rays in the K-capture branch of energies 0·556, 0·576, 0·722, 1·271 and 1·300 MeV. These define excited levels in Cd^{114} of energies 0·556, 1·278 and 1·856 MeV above the ground state. The end point of the β^- spectrum is at 1·984 ± 0·004 MeV. A.

537.533.73 : 548.74

The theory of electron diffraction. *See Abstr.* 2837

537.533.8

2492. Ionization loss at relativistic energies and polarization effects. M. SCHÖNBERG. Letter in *Nuovo Cimento*, **9**, 372–5 (*April*, 1952).

Fermi's calculation of the rate of energy loss by a relativistic charged particle due to distant interactions is modified by first omitting the atoms closer to the particle path than $R \sim \sqrt{(mc^2/4\pi Ne^2)}$. As a result, the Cherenkov radiation is strongly reduced for wavelength $\lambda < R$, but little affected for $\lambda > R$. The effect of atoms closer than R is calculated from the Bethe–Bloch–Williams theory. The expression for the total ionization can then account for recent experimental results. R. H. DALITZ

537.533.8

2493. Radiation characteristics of high-energy electron accelerator targets. J. D. LAWSON. *Nucleonics*, **10**, 61–5 (*Nov.*, 1952).

Expressions are given for the energy and angular distributions of photons ejected from thin and moderately thick targets by high-energy electrons (above 5 MeV). The energy distribution of the forward and integrated radiation ejected from a thin target ($Z = 78$) by 24·5 MeV electrons is graphed and radiation lengths in various elements tabulated. Qualitative observations are made concerning the radiation from very thick targets. L. R. SHEPHERD

537.533.8

2494. The secondary emission from copper and silver films obtained with primary electron energies below 10 eV. H. P. MYERS. *Proc. Roy. Soc. A*, **215**, 329–45 (*Dec.* 5, 1952).

An apparatus for the investigation of the secondary electron emission from freshly evaporated Cu and Ag films obtained with primary electron energies between thermal energies and 10 eV is described. The measured secondary emission ratios show a definite dependence upon primary electron energy which is different from that determined by previous workers. Furthermore, the values of the secondary emission ratio are lower than those hitherto recorded, both Ag and Cu possessing a secondary emission ratio less than 0·1 in the primary energy range 1 to 5 eV. The difference between the results presented in this paper and those obtained by earlier workers is attributed to the improved vacuum conditions which were used in the present work, thereby preventing the troublesome effects of contamination of the surfaces under investigation by the residual gases in the experimental tube. The energy distribution of the secondary electrons was measured and showed that at very low energies (less than 5 eV) these electrons are in fact elastically reflected primary electrons. A.

537.533.9

2495. Electron-induced showers in copper. A. KANTZ AND R. HOFSTADTER. *Phys. Rev.*, **89**, 607–17 (*Feb.* 1, 1953).

An experimental determination has been made of the radial and longitudinal distribution of energy produced in showers initiated by electrons of 118 MeV and 157 MeV in Cu. A small crystal CsBr(Tl) coupled to a thin light pipe and photomultiplier was used as a probe. Graphs of the radial distributions are given from which, by numerical integration, transition curves are determined. Calculations are made for an approximately optimum design of scintillation crystal [e.g. NaI(Tl)] to capture a large fraction of the energy within a shower. A.

537.533.92 : 551.594.21

High energy electrons produced in a thunderstorm. *See Abstr.* 2853

537.534 : 621.3.013 : 621.384.611

2496. Electric fields within cyclotron dees. R. L. MURRAY AND L. T. RATNER. *J. appl. Phys.*, **24**, 67–9 (*Jan.*, 1953).

Formulae for the electric field strength parallel to and perpendicular to the magnetic field for an idealized cyclotron dee system are derived by use of the Schwarz–Christoffel transformation. A convenient method for computing numerical values for any geometry characterized by the ratio of dee gap to dee height is presented and applied. A.

537.534 : 621.384.611

2497. Radial oscillations in the cyclotron. P. V. C. HOUGH. *Rev. sci. Instrum.*, **24**, 42–8 (*Jan.*, 1953).

The excitation and evolution of the radial oscillations of ions has been studied theoretically and experimentally. A simple method for calculating the pattern of the oscillations leads to detailed criteria for the preparation of the magnetic field and a systematic theory of shimming. A new method for measuring the pattern of the oscillations is used to check the theory. The results are applied briefly to the problem of beam extraction.

537.534.74

2498. On Jastrow's interaction and the elastic scattering of high energy protons by deuterons. B. H. BRANSDEN. *Proc. Phys. Soc.* [*London*] *A*, **65**, 972–7 (*Dec.*, 1952).

An approximate method has been used to calculate the elastic total and differential cross-sections for p–d scattering, at incident proton energies of 150 and 240 MeV. A nuclear interaction has been assumed of a type suggested by Jastrow, containing an infinite repulsive core in singlet two-body states. Of the various phenomenological interactions, this agrees about the best with the high energy n–p and p–p scattering data. The calculated angular distribution near 90°, in the centre-of-mass system, is found to be of the right order of magnitude, but agreement with experiment in the forward and backward directions is poor. An explanation of this result is suggested. A.

537.534.74

2499. The energy dependence of the phase shift in proton-proton scattering. H. ÙBERALL. *Acta phys. Austriaca*, **6**, *No.* 2-3, 119–34 (1952) *In German.*

An expansion of a simple function of the phase shift in powers of the energy is derived using boundary conditions at the nuclear surface. The coefficients are calculated explicitly in terms of modified Bessel functions, the first two being related to the "scattering length" and the "effective range." W. J. SWIATECKI

537.534.74

2500. Elastic scattering of 6·5-MeV protons from copper. L. M. GOLDMAN. *Phys. Rev.*, **89**, 349–52 (*Jan.* 15, 1953).

The 6·5 MeV protons from the 27 in. Rochester cyclotron have been used to determine the angular distribution of protons elastically scattered from copper. Significant differences from pure Coulomb scattering were observed. The results have been compared with the predictions of the Feshback–Weisskopf schematic theory and appear to disagree with these. A.

537.534.74

2501. Interpretation of high energy *p–p* scattering. D. R. SWANSON. *Phys. Rev.*, **89**, 740–8 (*Feb.* 15, 1953).

A study is made of the scattering of high-energy protons by protons. Several types of "cutoffs" are introduced into the singular tensor interaction proposed by Christian and Noyes; the triplet *P* state radial equations are then solved by essentially exact numerical integration methods. The resulting cross-sections show a more pronounced disagreement with experiment than do the Born approximation cross-sections of Christian and Noyes. Calculations were carried out in the vicinity of 350 MeV and 120 MeV. A.

537.534.74

2502. Polarization effects in nucleon-nucleon scattering. D. R. SWANSON. *Phys. Rev.*, **89**, 749–52 (*Feb.* 15, 1953).

If a beam of unpolarized nucleons is scattered from a target of unpolarized nucleons, the scattered particles are polarized (in a direction normal to the scattering plane) provided that the interaction contains tensor or spin-orbit forces. The polarization can be detected by means of a second similar scattering since the cross-section then contains an azimuthal dependence: $I(\theta, \phi) = I_0(\theta)(1 + \varepsilon \cos \phi)$, where $\varepsilon(\theta)$ is essentially the square of the polarization. Calculations are carried out by the author for a double *p–p* scattering using the tensor interaction described in the preceding abstract, and a double *n–p* scattering using the central and tensor potential of Christian and Hart (containing the "half-exchange" dependence proposed by Serber). The polarization produced by the first scattering at the optimum angle of $\theta \simeq 50°$ was found to vary from 6% at 40 MeV to 33% at 285 MeV for *n–p* scattering and from 10% at 129 MeV to 15% at 350 MeV for *p–p* scattering. The *n–p* results [Abstr. 3012 (1952)] are consistent with the azimuthal asymmetry detected in a double scattering experiment reported by L. Wouters. A.

537.534.74 : 539.172.13

The electric scattering of deuterons. *See Abstr.* 2703

DISCHARGE TUBES . COUNTERS 537.54

537.542

2503. On the breakdown of Geiger–Müller counters at high overvoltages. H. DE VRIES AND G. W. BARENDSEN. *Physica*, **18**, 927–32 (*Nov.*, 1952).

The relation between the length of a counter and the width of its plateau is measured. From the results an explanation is derived for the well-known breakdown of vapour quenched counters at high overvoltages: probably the disturbing afterdischarges are triggered by complex ions or molecules which form in the field free region around the wire at high overvoltages. A.

537.542 : 537.312.5

2504. On the photosensitivity of glass self-quenching Geiger–Müller counters with external cathode. H. SCHWARZ. *Notas de Fisica, No.* 7, 8 *pp.* (1952).

The development of photosensitivity in Geiger–Müller counters is investigated. A wall effect is found due to ionization of adsorbed molecules and a volume effect in the gas attributed to negative molecular oxygen ions. G. F. J. GARLICK

537.542 : 539.166

An automatic recording gamma-ray spectrometer. *See Abstr.* 2673

537.542 : 621.318.572

2505. Pulse-amplitude analysis in nuclear research. IV. A. B. VAN RENNES. *Nucleonics*, **10**, 50–6 (*Oct.*, 1952).

For Pt III, see Abstr. 929 (1953). Three further types of analyser are described. The first a 20-channel instrument, using fairly conventional discriminators, preceded by an expander amplifier, has an inspector circuit, which permits only the analysis of pulses, preceded or followed by a 2·3 μsec interval. Channel width stability is expected to be of the order of 1%. The other analysers both employ amplitude-to-time conversion. The first, due to Wilkinson, employing 99 channels, has a resolving time of 0·1 sec, governed by the speed of operation of mechanical relays and registers. A notable feature of the second instrument (Hutchinson and Scarrot) is the storage of the information in a mercury delay line and its presentation on the screen of a c.r.t. In both these analysers, the deviation from linearity and channel width stability are reduced to about one part per thousand. Photographic methods of pulse height analysis involving the photographing of a c.r.t. screen, are reviewed briefly. L. R. SHEPHERD

537.542 : 621.318.572

2506. On the use of a Rosenblum counter with coincidence systems of short response times. T. MULLER, R. RICHERT AND S. GORODETZKY. *C.R. Acad. Sci.* [*Paris*] **235**, 1385–6 (*Dec.* 1, 1952) *In French.*

A Rosenblum spark counter is used with a Bay coincidence circuit [Abstr. 7039 (1951)] with variable delay line in one channel. The complete system has a resolving time of about 10^{-10} sec and the rise time of the Rosenblum counter is considered to be less than this value. G. F. J. GARLICK

537.542 : 518.4

2507. Graphical analysis of cloud-chamber photographs. J. S. Campbell and D. F. Welch. *Nucleonics*, **10**, 62–5 (*Dec.*, 1952).

The graphical method of analysing cloud-chamber photographs, taken stereoscopically in two cameras, is outlined. The measurement of lengths and directions of straight tracks, angles between intersecting tracks, position of isolated droplets and radius of curvature and pitch of helical tracks in a magnetic field, are considered. L. R. SHEPHERD

IONIZATION . THERMIONICS 537.56/.58

537.56

2508. Experimental investigation of the diffusion of slow electrons in nitrogen and hydrogen. R. W. Crompton and D. J. Sutton. *Proc. Roy. Soc. A*, **215**, 467–80 (*Dec.* 22, 1952).

Presents the results of precise measurements of the diffusion of slow electrons in hydrogen and nitrogen in the presence of a uniform electric field. Such measurements lead directly to the value of Townsend's energy coefficient (k_T) as a function of Z/p (field strength/gas pressure). Since the drift velocity (W) of the electrons is also known (Nielsen and Bradbury, 1936), the following physical quantities are deduced as functions of Z/p: mean free path of the electrons at unit pressure, mean energy lost by an electron per collision and the collisional cross-sections of the molecules. Measurements of the diffusion were obtained from two apparatuses which differed in dimensions and metal of the electrodes. The range of gas pressures employed was 3 to 14 mm Hg. A table shows that the values of k_T as a function of Z/p derived from these measurements agree (with one exception) to within 3%, and it is therefore considered that the measurements are trustworthy. The results are presented graphically and in tabular form. A.

537.56

2509. Production of negative ions and noise in negative ion beams. W. L. Fite. *Phys. Rev.*, **89**, 411–15 (*Jan.* 15, 1953).

In a search for high current sources of low energy (~100 eV) negative atomic ions of hydrogen and oxygen, five types of sources were examined. The most promising practical source for both H^- and O^- was found to be the d.c. glow discharge from which beams of 10^{-7} ampere of either ion could be drawn. Hot cathode arc discharges yielded H^- currents of 7×10^{-8} ampere. R.F. discharges, hollow cathode discharges, and sources involving the Arnot effect seem inferior as high current sources. Two results were found which are of interest both for the mechanism of the discharge and for the production of negative ions. First, the most copious source of negative ions seems to be the anode side of well-formed striations such as are present in the two superior sources. Second, when either of these sources is used, the beam noise in the low audiofrequency range is much greater than shot noise and is related to fluctuations in the striations. A.

537.56

2510. Ionization probability curves for krypton and xenon near threshold. R. E. Fox, W. M. Hickam and T. Kjeldaas, Jr. *Phys. Rev.*, **89**, 555–8 (*Feb.* 1, 1953).

The shapes of the curves have been determined near the ionization potential by measuring the ionization produced by nearly monoenergetic electrons in a mass spectrometer. Ionization processes associated with the $^2P_{\frac{1}{2}}$ and $^2P_{\frac{3}{2}}$ ground states of the ions are clearly resolved. Ions are observed which are attributed to auto-ionization of atoms excited to the higher states having the $^2P_{\frac{1}{2}}$ core configuration. A.

537.563

2511. Positive ions formed by an open electric heater. R. Siksna. *Ark. Fys.*, **5**, *Paper* 25, 531–43 (1952).

An analysis showed that the predominant fraction of the positive ions produced belongs to the large-intermediate ions, but ultra-large, Langevin large and lighter ions are also present, the two last groups in smaller quantities. Ordinarily the number of positive ions produced increased during the heating, reaching a saturation. This increase may be regarded as an indication that the established ions cannot be produced by direct emission of positive ions from the heater. Because negative ions were present in a too small quantity, no detailed investigation of them was carried out. Some indications for further investigations are given. A.

537.564

2512. Ions produced in the air at atmospheric pressure by ultra-violet light from a quartz-mercury arc. H. Norinder and R. Siksna. *Ark. Fys.*, **5**, *Paper* 23, 471–91 (1952).

The following facts have been inferred: formation of ions of both polarities during irradiation; the number of negative ions formed is greater than that of positive ions; the difference between the number of negative and positive ions formed is greater at lower than at higher temperature; the prevailing quantity of formed ions is of the kind of large ions; from the beginning of irradiation ions with higher mobility are formed, during illumination the mobility of the ions present will be transformed into lower values. A discussion of possible causes of the processes of formation of observed ions is given. The probable chemical processes playing a role in processes of formation of ions by u.v. light are considered. A.

537.565

2513. Mobility spectra of ions formed in a room by negative corona discharge. R. Siksna. *Ark. Fys.*, **5**, *Paper* 26, 545–63 (1952).

Mobility spectra of ions formed by negative wire corona were determined by successive characteristics obtained with periodical alternation of chosen adjusted limit mobilities of an ion-counter. Groups of ions in several regions of mobility were inferred and their transformation was pursued. A theoretical consideration of the used method is given. A.

537.565

2514. Drift velocity of ions in oxygen, nitrogen, and carbon monoxide. R. N. VARNEY. *Phys. Rev.*, **89**, 708–11 (*Feb.* 15, 1953).

The drift velocities of ions of the parent gas in O, N and CO have been measured as a function of field strength to pressure ratio by techniques previously reported. O gave results similar to those in the rare gases reported previously. A log-log plot of drift velocity against E/p_0 in volts/(cm × mm Hg) starts with a slope near unity which gradually decreases to one-half at high values of E/p_0. The mobility, extrapolated to zero field and atmospheric pressure is 2·25 cm²/volt-sec. N and CO both show a novel characteristic; the drift velocity first rises with E/p_0 but reaches a maximum and actually decreases, then finally resumes a more normal rise with E/p_0 as described for O. It is believed that at high E/p_0 the drift velocity is characteristic of N_2^+ ions and CO^+ ions, respectively. At low fields the ion in N is believed to be N_4^+. In CO the ion at low fields is believed to be CO^+, with $(CO)_2^+$ being formed at intermediate fields. The results are complicated by an additional ion which appears in the range of E/p_0 from 95 to 250 and which has a higher speed than the other ion. It is suspected of being C^+. A.

537.568

2515. Electron capture by protons passing through hydrogen. J. D. JACKSON AND H. SCHIFF. *Phys. Rev.*, **89**, 359–65 (*Jan.* 15, 1953).

A theoretical calculation is made of the capture of an electron by a particle of charge $Z'e$ passing a hydrogen-like atom of charge Ze. Numerical results are presented for protons passing through hydrogen gas. In contrast to earlier treatments of this problem, the complete interaction Hamiltonian is retained as the perturbation causing the electron transfer. Previous workers assumed that the interaction between the incident particle and the electron was the only perturbation causing the transition and ignored the interaction between the incident particle and the nucleus of the atom. Such a neglect is unjustified. The results of this paper show that when the complete interaction is used the agreement between theory and experiment is good for all energies greater than 25 keV ($hv/e^2 \geqslant 1$) in the case of protons in hydrogen, even though the Born approximation is employed. This is a marked improvement over previous calculations which were approximately four to five times larger than experiment. A.

537.583

2516. Thermionic constants of metals and semiconductors. II. Metals of the first transition group. S. C. JAIN AND K. S. KRISHNAN. *Proc. Roy. Soc. A*, **215**, 431–7 (*Dec.* 22, 1952).

The method described in Pt I [Abstr. 5868 (1952)] for the determination of the thermionic constants of graphite, which is based on finding the saturation vapour pressure of the electron gas in a graphite chamber at different known temperatures, and applying the well-known thermodynamic relation of Clausius and Clapeyron, can be used for determining the constants of most metals by simply coating the inner walls of the graphite chamber with a thick layer of the metal to be studied. The present part reports measurements made by this method of the thermionic constants of the metals of the iron group from Ti to Ni. A.

537.583

2517. Periodic deviations in the Schottky effect for molybdenum. E. G. BROCK, A. L. HOUDE AND E. A. COOMES. *Phys. Rev.*, **89**, 851–4 (*Feb.* 15, 1953).

Periodic deviations have been measured over a field range of 10^4 to 10^5 volts cm^{-1} in a temperature range of 1400 to 1800°K. The results, interpreted in terms of the two reflection parameters λ and μ, justify the assumption of a mirror image barrier for the emitted electrons. A.

537.583 : 621.385.032.21

2518. On the Shottky equation of thermionic emission. H. BONIFAS. *Rev. gén. Elect.*, **61**, 539–40 (*Nov.*, 1952) *In French.*

Criticizes the derivation of Schottky's equation on the grounds that Schottky adds to the field potential, measured with respect to cathode, an image potential measured with respect to a point at infinity. The corrected result is

$$J = J_0 \exp\left[-e^{\frac{3}{2}}(I_0^{\frac{1}{2}} - F^{\frac{1}{2}})/kT\right], \; I_0 = e/2x_0$$

and x_0 = critical distance beyond which the image force law is obeyed. The hypothesis of a Coulomb force law is discussed. A. H. W. BECK (R)

537.583 : 621.385.032.216

2519. Thermionic emission from oxide-coated tungsten filaments. C. P. HADLEY. *J. appl. Phys.*, **24**, 49–52 (*Jan.*, 1953).

A study has been made of thermionic emission from tungsten filaments cataphoretically coated with alkaline earth oxides. It was found that the emission from the oxide-coated filament was not influenced by the variation of work-function with crystallographic direction of the base metal. A Richardson plot of emission at zero field yielded an apparent work function of 1·3 volts and an A value of 0·048 amp/cm²-deg². In retarding potential data, the energy of thermionic electrons showed an apparent deviation from Maxwell–Boltzmann statistics. This deviation was interpreted as due to a potential drop through the coating. Such an interpretation led to a conductivity activation-energy of 1·3 volts. A strip theory of patches was used to explain the accelerating potential data. Satisfactory agreement with experiment was found with a patch amplitude of 0·2 volt and a period of 2×10^{-6} meter. A.

COSMIC RAYS 537.591

537.591.1

2520. On the ratio of the number of mesons to the number of heavy particles observed in nuclear emulsions exposed at Puy-de-Dôme. S. DESPREZ-REBAUD. *C.R. Acad. Sci.* [*Paris*] **235**, 1386–8 (*Dec.* 1, 1952) *In French.*

537.591.1

2521. Measurements of the cosmic radiation underground. E. Fenyves and O. Haiman. *Acta phys. Hungar.*, **2**, *No.* 1, 93–5 (1952).

The radiation at a depth of 650 m water equivalent has been investigated by measuring two-, three- and fourfold coincidence rates with a counter telescope. The threefold and fourfold rates are found to be the same but they are appreciably smaller than the twofold rate, and it is shown that this difference, which is independent of zenith angle and which is reduced to half its value by 5 mm Pb, is probably due to local radioactivity. From absorption measurements in Pb it is concluded that the three and fourfold coincidences are due to mesons. H. ELLIOT

537.591.1

2522. Negative primaries as part of cosmic radiation. B. Bhowmik. Letter in *Phys. Rev.*, **89**, 327 (*Jan.* 1, 1953).

The observed values of the east-west asymmetry at latitudes 0° and 20° for various zenith angles and atmospheric depths are compared with calculated values. It is shown that the best agreement between theory and observation is obtained if it is assumed that 20% of the primary radiation is negatively charged. H. ELLIOT

537.591.15

2523. Absorption of gamma radiation in thick layers of lead and the second maximum in the shower curve of cosmic radiation. J. Clay, C. Wansdronk and T. J. Dekker. *Physica*, **18**, 582–6 (*Aug.–Sept.*, 1952).

Concerning the absorption of γ-rays in thick layers of Pb (20–30 cm) some authors report irregularities and think that these may be the origin of the second maximum and of a third maximum (if any) in the shower curve of cosmic radiation. Careful measurements were therefore made of the absorption of γ-radiation of about 30 mC Na^{24} (2·7 MeV) and of 100 mC of Ra (1·7–2·2 MeV) by layers of Pb from 10 to 30 cm. No irregularities exceeding the uncertainty of observation have been found. A.

537.591.15

2524. On the collision cross-sections in penetrating cosmic-ray showers. K. Sitte. *Acta phys. Austriaca*, **6**, *No.* 2–3, 167–80 (1952) *In German.*

The discrepancies between counter and emulsion (or cloud chamber) experiments as regards high-energy collision cross-sections is traced, on the basis of recent cloud chamber + counters experiments [Abstr. 7385 (1952)], to an inexact interpretation of the counter data. When this is corrected there is satisfactory agreement of all methods in giving "geometrical" cross-sections for $E \gtrsim 0{\cdot}75 \times 10^9$ eV. The "transparency" of light nuclei seems partly or wholly ascribable to this cause. W. J. Swiatecki

537.591.15

2525. Further results from the study of sea-level penetrating showers. W. Y. Chang, G. Del Castillo and L. Grodzins. *Phys. Rev.*, **89**, 408–11 (*Jan.* 15, 1953).

Thirty-five non-ionizing link showers (produced at a 17 g/cm² Pb plate) associated with sea-level penetrating showers are presented. These have their axes oriented toward the origins of the penetrating showers and are believed to be cascade electronic showers initiated by high-energy photons, which are probably produced from the decay of π^0 mesons among the penetrating shower particles. The size distribution of these showers is given showing a spread from 2 to 20 particles per shower. The angular distribution of their axes with respect to the penetrating shower axes is also approximately determined. Shower particles (of the penetrating showers) scattered by Be and Pb at angles greater than 10°, 15°, 20°, 30° and 40° have been observed. The mean free path against scattering, and the corresponding scattering cross-section per nucleon have been estimated in each case. The total scattering cross-section per nucleon is of the order of magnitude of several millibarns. This figure may be compared with the total theoretical meson-nucleon scattering cross-section calculated from pseudoscalar or scalar theory for meson energy equal to several times its rest energy. Perhaps, it is several times smaller than the total experimental nucleon-nucleon scattering cross-section for, say, 300 MeV proton energy. The experimental cross-section probably represents the combined effect of meson-nucleon and nucleon-nucleon scattering. A.

537.591.15

2526. The secondaries of penetrating showers. C. C. Damm. *Phys. Rev.*, **89**, 826–31 (*Feb.* 15, 1953).

The momentum spectrum of penetrating shower secondaries at 11 200 ft altitude has been measured by means of the distribution in projected angle of the multiple Coulomb scattering of those particles in a lead plate of a cloud chamber. The resulting spectrum is compared to that obtained for the meson secondaries of stars in photographic plates exposed at 70 000 ft. For mesons above 500 MeV, the two spectra coincide within the errors. At lower energies, and especially around 100 MeV, a marked difference exists. The respective average energies are also different by a factor of about two. All of these differences appear to result both from selecting particles emitted in the forward direction, and from higher energies of the particles producing the primary event in the present experiment. The average "primary energy" appears to be less than 8 BeV, which is a lower value than one might deduce from the latitude effect of penetrating showers. A production of photons in carbon by the penetrating shower secondaries has been observed. Interpreted in terms of π^0 production, this is consistent with the photographic plate work that has suggested inelastic charge exchange scattering. Three decays of neutral V^0 particles observed show that the cross-section for V^0 production by the penetrating shower secondaries is most likely an appreciable fraction of the geometrical cross-section. A.

537.591.5

2527. On the angular distribution, the momentum spectrum and the E–W asymmetry of the cosmic-ray nucleon component studied using a nuclear emulsion. M. Morand and Tsai-Chü. *C.R. Acad. Sci.* [*Paris*] **235**, 1502–4 (*Dec.* 10, 1952) *In French.*

Tracks of more than twice minimum grain density were recorded in a vertically exposed G5 emulsion, and ascribed to protons. With α the angle of the projection of the track to the vertical, the angular distribution was found to be $I = I_0 \cos \lambda\alpha$, with

$\lambda = 2{\cdot}56 \pm 0{\cdot}28$ for $\alpha < 60^0$, and the vertical intensity $(1{\cdot}625 \pm 0{\cdot}072)10^{-4}$ cm^{-2} sec^{-1} sterad^{-1}. The momentum spectrum is approximately constant at $3 \cdot 10^{-7}$ cm^{-2} sec^{-1} sterad^{-1} (MeV/c)$^{-1}$. The E–W assymetry is most pronounced for particles with $30 < \alpha < 45°$. E. P. GEORGE

537.591.8

2528. On the penetrating secondary component of μ-mesons. D. KESSLER AND R. MAZE. *Physica*, **18**, 528–48 (*Aug.–Sept.*, 1952) *In French.*

A description of several experiments giving evidence for the existence of a penetrating secondary radiation at sea-level and underground. This radiation would be formed of showers of particles whose range is 42 ± 3 g/cm^2, probably similar to those found by George and Evans in nuclear emulsions. Cross-section for the creation of these showers by μ-mesons is about $1{\cdot}6 \times 10^{-29}$ cm^2 per nucleon. A.

537.591.8

2529. A counter-hodoscope study of associated penetrating particles underground. B. LEONTIC AND A. W. WOLFENDALE. Letter in *Phil. Mag.*, **43**, 1335–8 (*Dec.*, 1952).

The production of pairs of penetrating particles has been examined at a depth of 26 m.w.e. and the interaction length for the secondary particles is found to be 14 ± 4 cm Pb. It is concluded that the secondary is a nuclear interacting particle—possibly a π-meson. The results are discussed in relation to those of other workers. H. ELLIOT

537.591.8

2530. Experimental verification of theories of ionization produced in gases by high-energy mesons. P. CHANSON, P. TREILLE, T. PRICE AND D. WEST. *C.R. Acad. Sci.* [*Paris*] **235**, 1500–2 (*Dec.* 10, 1952) *In French.*

At an altitude of 3650 m, the pulse-size/frequency distributions of particles crossing 4 rectangular proportional counters were compared for two groups of mesons selected by lead absorbers. The results indicate an increase of ionization for high-energy mesons. E. P. GEORGE

MAGNETISM 538

538.11 : 525.241

2531. A negative experiment relating to magnetism and the earth's rotation. P. M. S. BLACKETT. *Phil. Trans A*, **245**, 309–70 (*Dec.* 16, 1952).

A detailed study of the possibility of making a direct test of the Schuster–Wilson hypothesis, by measuring the very small magnetic field of the order of 10^{-9} G which would be produced by a rotating body of reasonable size in the laboratory, led to the conclusion that the experiment would perhaps be possible but would certainly be exceedingly difficult. However, a much easier but still worth-while subsidiary experiment presented itself. This was to test whether a massive body, in fact a 10×10 cm gold cylinder, at rest in the laboratory and so rotating with the earth, would appear to an observer, also rotating with the earth, to produce a weak magnetic field with a magnitude of the order of 10^{-8} G. That such a field might exist is a plausible deduction from a particular form of the Schuster–Wilson hypothesis considered in some detail by Runcorn and by Chapman. This paper describes the design, construction and use of a magnetometer with which this "static-body experiment" was carried out. It was necessary to investigate the theory and use of such an instrument in considerable detail. The bulk of this paper is concerned with this instrumental study. The actual static-body experiment is described and it is there shown that no such field as is predicted by the modified Schuster–Wilson hypothesis is found. This result is in satisfactory agreement with the independent refutation of the hypothesis by the measurements by Runcorn and colleagues of the magnetic field of the earth underground. When the magnetometer was completed it was found to be very suitable for the measurement of the remanent magnetism of weakly magnetized specimens, in particular certain sedimentary rocks. A.

538.113

2532. A theory of the paramagnetism of uranyl-like ions. R. J. ELLIOTT. Letter in *Phys. Rev.*, **89**, 659 (*Feb.* 1, 1953).

Interprets the paramagnetic susceptibility of the ions $(NpO_2)^{++}$ and $(PuO_2)^{++}$ in compounds isomorphous with $Na(UO_2)(C_2H_3O_2)_3$ as due to the $5f$ electrons. A formula is given for $(NpO_2)^{++}$ giving the temperature variation of p_B, the measured values corresponding to $\Lambda = 3$ and spin-orbit parameter $\zeta = 500$ cm^{-1}. The observed constant value of p_B for $(PuO_2)^{++}$, 2·82, is in good agreement with that calculated. The information derivable from paramagnetic resonance experiments is discussed, and the effects on the results of the action of the crystalline field is considered. E. P. WOHLFARTH

538.113 : 538.224

2533. Anisotropic susceptibility of polycrystalline graphite. W. P. EATHERLY AND J. D. MCCLELLAND. Letter in *Phys. Rev.*, **89**, 661 (*Feb.* 1, 1953).

It is shown theoretically, and verified by observation on polycrystalline graphite specimens, that the susceptibility tensor for an assembly of anisotropic crystals with arbitrary preferred orientation has an invariant spur. Explicitly $\sum_1^3 \chi_m = \text{spur } \chi$, where the χ_m are the mass susceptibilities in three orthogonal directions of the polycrystalline specimen and χ the susceptibility tensor for the single crystal. E. P. WOHLFARTH

538.114

2534. Statistics of the three-dimensional ferromagnet. I. The variational method. B. MARTIN AND D. TER HAAR. *Physica*, **18**, 569–81 (*Aug.–Sept.*, 1952).

The variational method developed by Kramers and Wannier (1941) is applied to the Ising model of a simple cubic ferromagnet and in this way equations are derived from which the approximate values of the partition function, and thus of the configurational energy and specific heat, can be obtained. These equations are solved both by series expansions and by numerical methods at temperatures above the Curie temperature. A.

538.114

2535. Statistics of the three-dimensional ferromagnet. II. Comparison of various approximation methods. D. TER HAAR. *Physica*, **18**, 836–40 (*Nov.*, 1952).

A rigorous series expansion for the partition function per spin for a three-dimensional simple cubic ferromagnet in decreasing powers of the absolute temperature,

$$\frac{1}{2}\lambda = 1 + \frac{3}{2}K^2 + \frac{31}{8}K^4 + \frac{5\,461}{240}K^6 + \frac{2\,436\,211}{13\,440}K^8 + \ldots \quad (K = J/2kT)$$

is found and compared with expansions obtained by various approximation methods. A.

538.114

2536. Zener's treatment of ferromagnetism. A. TEVIOTDALE. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 957–8 (*Nov.*, 1952).

A brief critical discussion of Zener's work [Abstr. 4616, 5670, 7195 (1951); 2832 (1952)]. The correct conditions for equilibrium of the spin system are derived, Zener's single condition being shown to be applicable in only very restricted circumstances. Calculated saturation moments differ from those observed. Carr's calculations [Abstr. 3718 (1952)] are also criticized. The probable course of the temperature variation of the susceptibility on Carr's model is discussed. E. P. WOHLFARTH

538.221/222

2537. Microwave resonance absorption in gadolinium metal. A. F. KIP, C. KITTEL, A. M. PORTIS, R. BARTON AND F. H. SPEDDING. Letter in *Phys. Rev.*, **89**, 318 (*Jan.* 15, 1953).

g values $\sim 1{\cdot}95$ were obtained in ferromagnetic (<6°C) and paramagnetic absorption experiments at 24 300 Mc/s and slight coupling of the ^8S, $4f^7$ shell with the $5d$ orbit is postulated. D. H. WHIFFEN

538.221

2538. The magnetic susceptibilities of an antiferromagnetic single crystal of $CuCl_2.2H_2O$. J. VAN DEN HANDEL, H. M. GIJSMAN AND N. J. POULIS. *Physica*, **18**, 862–76 (*Nov.*, 1952).

The magnetization of single crystals of $CuCl_2.2H_2O$ has been measured as a function of temperature, magnetic field strength and the direction of the magnetic field relative to the axes of the crystal. For temperatures between 14°K and 300°K the susceptibility follows a Curie–Weiss law. In the temperature region of liquid helium the crystals become antiferromagnetic, the transition temperature being in the neighbourhood of 4·3°K. The results are compared with the theories of Néel, Van Vleck and Gorter and Haantjes. In general there is good agreement. A.

538.221

2539. The influence of oxygen, contained in high purity irons in the form of a solid solution, on certain of their magnetic properties in weak alternating fields. J. BOURRAT, G. CHAUDRON AND I. EPELBOIN. *C.R. Acad. Sci.* [*Paris*] **235**, 1290–2 (*Nov.* 24, 1952) *In French.*

It is known that the coercive force and the maximum permeability are not direct functions of the degree of purity of the iron. This is not the case for magnetic properties in weak alternating fields and the authors have established the relationship between certain of these properties and the O_2 content in the form of a solid solution in iron which is otherwise pure. V. G. WELSBY

538.221

2540. Spectroscopic g factors of ferromagnetic nickel-copper alloys. A. J. P. MEYER. *C.R. Acad. Sci.* [*Paris*] **235**, 1382–4 (*Dec.* 1, 1952) *In French.*

Describes room temp. measurements for pure nickel and 5 alloys with copper concentrations up to 28%. The measured g values are close to 2·20, independently of composition. E. P. WOHLFARTH

538.221

2541. Investigation of [the compound] Fe_5CuO_8. F. BERTAUT AND C. DELORME. *C.R. Acad. Sci.* [*Paris*] **236**, 74–6 (*Jan.* 5, 1953) *In French.*

The compound was found to have a spinel structure, to have a magnetic moment corresponding to $p_B = 8{\cdot}21$, corresponding closely to random distribution of the Cu ions among the A and B lattice sites, and to be unstable after annealing at relatively low temperatures, with a change of p_B to 5·82. Possible reasons for the instability are given. E. P. WOHLFARTH

538.221 : 548.736.3

Crystal structure and antiferromagnetism in haematite. *See Abstr.* 2825

538.222

2542. On paramagnetic relaxation in chromium alum. F. W. DE VRIJER AND C. J. GORTER. *Physica*, **18**, 549–64 (*Aug.–Sept.*, 1952).

A new relaxation phenomenon is detected in CrK alum. Apparently it is connected with the establishment of thermodynamic equilibrium in the spin system. There are indications of the existence of two groups of energy differences in the spin system of this salt and the interaction between these two groups might account for the observed phenomena. CrCs and CrRb alum apparently do not show this new effect. Experiments concerning a possible anisotropy of this relaxation effect are not conclusive. A.

538.222

2543. The paramagnetic susceptibility of a free radical. J. VAN DEN HANDEL. *Physica*, **18**, 921–6 (*Nov.*, 1952).

The magnetic susceptibility of the free radical $C_{18}H_{21}N_2O_2$ was measured between room temperature and 1·56°K. Between 300°K and 4°K the susceptibility can be represented by a Curie–Weiss law: $\chi = C/(T + \Delta) - \chi_{dia}$, where $\Delta = 1{\cdot}5$. There seems to be some possibility of antiferromagnetic behaviour at temperatures below 1·5°K. A.

538.222

2544. Paramagnetic resonance in potassium ferricyanide. B. BLEANEY AND D. J. E. INGRAM. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 953–4 (*Nov.*, 1952).

The g-values along the a, b and c axes were found to be 2·30, 2·18 and 0·94 in good agreement with susceptibility measurements of Jackson (1938) and Guha (1951). Anomalously large line widths did not change on cooling from 20° to 12°K, showing that they are not due to spin-lattice relaxation. W. J. SWIATECKI

538.222

2545. The theory of the magnetic properties of rare earth salts: cerium ethyl sulphate. R. J. ELLIOTT AND K. W. H. STEVENS. *Proc. Roy. Soc. A*, **215**, 437–53 (*Dec.* 22, 1952).

The theory of a Ce^{3+} ion in a crystal is considered as that of a free ion with a single 4*f*-electron outside closed shells, and the effect of the surrounding lattice is included as a static crystalline electric field. The problem is solved when this field has C_{3h} symmetry. It is possible that this theory will be applicable to many cerium salts—it is here applied to the ethyl sulphate for which fairly extensive experimental data are available. It is found that in order to obtain agreement with experiment it is essential to consider small terms of C_{3v} symmetry, the presence of which is not incompatible with the crystal structure. It is then possible to determine values of the magnitudes of the crystal fields and to fit the magnetic resonance data accurately and the susceptibility data to within a small percentage. A.

538.222

2546. *F*-center wave functions and electronic *g*-values in KCl crystals. A. H. KAHN AND C. KITTEL. Letter in *Phys. Rev.*, **89**, 315 (*Jan.* 1, 1953).

Paramagnetic resonance in KCl crystals coloured by excess K has been ascribed to the *F*-centres [Abstr. 323 (1953)] and a splitting factor $g = 1{\cdot}995 \pm 0{\cdot}001$ obtained. The difference between this value and that of 2·0023 for a free electron cannot be explained if a simple *S*-state is assumed for the ground level of the *F*-centre. An improved wave function is obtained by mixing in of a *G*-state which then gives a value of $\Delta g = -1{\cdot}7\times10^{3}$. This would be greater if higher states were taken into account.

G. F. J. GARLICK

538.222

2547. Paramagnetic resonance in copper acetate at 47 000 Mc/sec. T. OKAMURA, Y. TORIZUKA AND M. DATE. Letter in *Phys. Rev.*, **89**, 525 (*Jan.* 15, 1953).

538.222

2548. Hyperfine structure in the paramagnetic resonance of the ion $(SO_3)_2NO^{--}$. J. TOWNSEND, S. I. WEISSMAN AND G. E. PAKE. *Phys. Rev.*, **89**, 606 (*Feb.* 1, 1953).

Paramagnetic resonance spectra of the free-radical ion $(SO_3)_2NO^{--}$ in dilute solutions were observed in fields up to 50 oersteds and at frequencies up to 120 Mc/s. The observed pattern of absorption lines agree well with that calculated for an *s*-electron coupled to a N^{14} (spin 1) nucleus. The zero-field splitting is $54{\cdot}7 + 0{\cdot}5$ Mc/s. A.

538.222

2549. Intensities of nuclear magnetic resonances in cubic crystals. G. D. WATKINS AND R. V. POUND. Letter in *Phys. Rev.*, **89**, 658 (*Feb.* 1, 1953).

The authors' measurements of 1951 with Br^{79}, Br^{81} and I^{127} in KBr and KI crystals and powders resulting in 0·3–0·4 of the expected intensities can be accounted for by assuming that all but the central one of the two I components into which a normal line is split by random electric fields in the crystal are smeared out and escape detection. Nuclei with a moderate quadrupole moment could serve as sensitive monitors of internal strains in a crystal. W. J. SWIATECKI

538.222

2550. Paramagnetic relaxation in metals. A. W. OVERHAUSER. *Phys. Rev.*, **89**, 689–700 (*Feb.* 15, 1953).

The paramagnetic relaxation time of electron spins in a metal is calculated. Relaxation processes due to interaction with lattice vibrations, nuclear spins, other electrons and impurity atoms are treated. It is found that the most important process of those considered is due to the interaction between electron magnetic moments and the fields caused by the translational motion of other electrons. A relaxation time of about one microsecond is calculated for this interaction at room temperature, and is approximately inversely proportional to the absolute temperature. A.

538.224

2551. Magnetic susceptibility of a diamagnetic electron gas—the role of small effective electron mass. E. N. ADAMS, II. *Phys. Rev.*, **89**, 633–48 (*Feb.* 1, 1953).

An exact formula for the "steady" bulk susceptibility of a degenerate electron gas is derived. The deviations from the Landau–Peierls formula are studied for several situations in which the effective electron mass is small. It is concluded that, in any case for which the Landau–Peierls susceptibility differs from the Landau susceptibility, the total susceptibility differs from the Landau–Peierls susceptibility by an amount of the same order of magnitude. The magnetic susceptibility of solid Bi is discussed on a model developed by H. Jones. It is found that for several reasons, Jones's model requires major modification. A particular modification is suggested as a possible basis for a theory of the Bi susceptibility. Some implications of the conclusions are discussed in connection with Bardeen's theory of superconductivity and the theory of the de Haas–van Alphen effect. A.

538.242

2552. The gyromagnetic ratio of Supermalloy. G. G. SCOTT. *Phys. Rev.*, **89**, 618 (*Feb.* 1, 1953).

The gyromagnetic ratio of Supermalloy has been determined by a highly refined magneto-mechanical method. The value obtained is $1{\cdot}030 \pm 0{\cdot}001$ times the mass-to-charge ratio of the electron. Within the limits of experimental error, this is the same value as has recently been reported for pure iron. A.

ELECTROMAGNETISM . ELECTRODYNAMICS
538.3/.5

538.3

2553. Electrodynamics. A. SOMMERFELD (Translated by E. G. RAMBERG] *New York, Academic Press* (1952) 371 + *xiii pp.* [Lectures on theoretical physics, Volume III.]

Review in *Rev. sci. Instrum.*, **24**, 58–9 (*Jan.*, 1953).

538.3 : 530.145

Gauge unvariance and classical electrodynamics. *See Abstr.* 2190

538.31 : 530.12

2554. Relativistic electrodynamics of magnets. G. MARX. *Acta phys. Hungar.*, **2**, *No.* 1, 67–84 (1952) *In German.*

Permanent magnets, as well as electrical charges, are considered as sources of the electromagnetic field. The relativistic field equations and the energy impulse tensor of the field are derived from a Lagrangian function. The force exerted on the magnets by the field is shown to equal the divergence of the energy impulse tensor. E. P. WOHLFARTH

538.311

2555. The definitions of magnetic flux density and field intensity. J. V. HUGHES. *Amer. J. Phys.*, **21**, 89–96 (*Feb.*, 1953).

The present theory of magnetism, in which it is treated as a phenomenon of current electricity, suffers from objections which are pointed out. The meanings of **B** and **H** on an atomic scale are considered, and a method of picturing **B** and **H**, inside a ferromagnetic body, without mentioning magnetic poles or dipoles, is developed. It is shown that this method satisfactorily accounts for the demagnetizing field in certain simple cases and that it also makes clear why **H** occurs in the circuital theorem while **B** is used in Laplace's equation. Rigorous definitions of **B** and **H** at any point in a magnetic medium are then developed. In the concluding section the advantages of the suggested method are summarized. A.

538.51 : 621.392.2

2556. Theory of the single-wire transmission line. T. E. ROBERTS, JR. *J. appl. Phys.*, **24**, 57–67 (*Jan.*, 1953).

Equations are derived for the current induced in an infinitely long, thin, straight wire of nonzero surface impedance when the wire is connected to a flanged coaxial line. Also, radiation field patterns are computed and the input conductance determined. It is found that the current (and likewise the input conductance) can be separated into two components, one of which is a propagating or modal current. Graphs are presented from which the efficiency of excitation of the propagating current can be computed. A second structure consisting of a single wire between perfectly conducting parallel plates is solved as a boundary-value problem. The solution is used in the discussion of the physical behaviour of a finite single-wire transmission line. In particular it is found that the usual transmission line concepts are valid under certain restricting conditions. A.

538.55 : 621.3.018.3

2557. The extinction of predominantly subharmonic oscillations in nonlinear systems. C. A. LUDEKE AND W. PONG. *J. appl. Phys.*, **24**, 96–7 (*Jan.*, 1953).

Describes the use of an electromechanical analogue to examine the limiting values of various parameters needed to destroy a predominantly subharmonic oscillation of order one-third, existing in a nonlinear system. The results of the analogue are then compared with the limiting values suggested by existing theory. A.

538.551

2558. Demonstrations to provide data for student computation in electricity. T. J. BLISARD AND B. A. GREENBAUM. *Amer. J. Phys.*, **21**, 109–11 (*Feb.*, 1953).

Two panel boards were devised for use in obtaining data for student computations in electricity, the first for study of Ohm's law and Kirchhoff's laws applied to networks, and the second for study of line loss in power transmission. The boards are effective teaching aids because of their good visibility and the ease with which circuits can be altered. The data are sufficiently precise to provide for results in agreement with physical laws. A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.565 : 621.396.611.4

2559. The complete system of electromagnetic normal modes of a biaxial anisotropic parallelepiped. E. HAFNER. *Acta phys. Austriaca*, **6**, *No.* 2–3, 209–18 (1952) *In German.*

Presents detailed derivations of solutions to Maxwell's equations for a rectangular cavity resonator completely filled by a monocrystalline biaxial dielectric whose principal axes of permittivity are parallel to the edges of the cavity. Electric ("*Z*-type") and magnetic ("*G*-type") solutions and their superposition are considered, and their completeness demonstrated by means of an extension from the uniaxial case.

F. F. ROBERTS

538.565 : 621.396.611.4 : 621.317.784.029.6

2560. A microwave vibration wattmeter. A. L. CULLEN. Letter in *Nature* [*London*] **170**, 1121–2 (*Dec.* 27, 1952).

A short horizontal dipole is suspended by a quartz fibre in a high-Q cavity terminating a waveguide. It tends to align itself parallel to the unperturbed electric field. When it is at 45° to this direction the cavity resonates and a very small angular change detunes it. By admitting microwave power cyclically to the cavity the dipole assumes a steady amplitude of mechanical oscillation and a simple formula then links the angle of oscillation and the power in the cavity at resonance. The result is independent of the Q of the cavity and the deflection falls off less rapidly with power than in other methods not employing this dual system of electrical and mechanical resonance. At 3·2 cm wavelength a light-beam deflection of 30 cm at 1 m distance can be obtained for about 100 mW power. E. D. HART

538.566 : 532.5

2561. A new type of propagation. C. H. PAPAS AND W. W. SALISBURY. *Trans Inst. Radio Engrs Prof. Group on Antennas and Propagation, No.* 4, 47–52 (*Dec.*, 1952).

H. Alfven and others have shown that when a conducting fluid is placed in a magnetic field the interaction of the electromagnetic and hydrodynamic forces generates a new type of wave, the magneto-hydrodynamic wave. Using a description of these

waves in an ideal fluid as a prototype, the authors briefly discuss their properties for various types of conducting fluids. A list of references is given. A.

538.566

2562. Addition theorems for spherical waves. B. FRIEDMAN AND J. RUSSEK. *New York Univ. (Washington Sq. Coll.) Math. Res. Group, Res. Rep. EM–44*, 19 *pp.* (*June*, 1952).

Expansions or "addition theorems" for the spherical wave functions $j_n(kR)P_n^{|m|}(\cos\theta)e^{im\phi}$, $h_n^{(1)}(kR)P_n^{|m|}(\cos\theta)e^{im\phi}$, and $h_n^{(2)}(kR)P_n^{|m|}(\cos\theta)e^{im\phi}$, with reference to the origin O, have been obtained in terms of spherical wave functions with reference to the origin O′, where O′ has the coordinates (r_0, θ_0, ϕ_0) with respect to O. Using the above-mentioned addition theorems, an expansion has been obtained for $e^{ikr_{12}}/r_{12}$, a wave which is spherically symmetric about the source Q, where Q is referred to the origin O, in terms of products of spherical waves with respect to origin O and spherical waves with respect to O′. A.

538.566

2563. The electromagnetic field in the plane of a circular aperture due to incident spherical waves. D. C. HOGG. *J. appl. Phys.*, **24**, 110–11 (*Jan.*, 1953).

Measurements have shown that the formula given by Andrews [Abstr. 7383 (1950)] for the field in the plane of a circular aperture illuminated by spherical waves requires modification. The envelope of the oscillations of amplitude in the slot is a function of position and a new formula is proposed.

G. D. SIMS

538.566 : 621.396.11

2564. Toward a theory of reflection by a rough surface. W. S. AMENT. *Proc. Inst. Radio Engrs*, **41**, 142–6 (*Jan.*, 1953).

A rough, perfectly reflecting surface is first specified by the statistics of noise theory. If illuminated by a plane electromagnetic wave, such a surface would reflect statistically predictable fields. An attempt is made to formulate the problem of predicting the fields in terms of the statistics of the surface. The result is a series of integral expressions in which averages of the currents induced in the surface appear as unknown functions. Owing to mathematical complexities, these expressions are not solved for the average currents; however, a qualitative discussion is given of a known formula for the specular reflection coefficient of a gently rolling surface. A.

538.566 : 621.396.671

2565. Diffraction patterns in circular apertures less than one wavelength in diameter. H. L. ROBINSON. *J. appl Phys.*, **24**, 35–8 (*Jan.*, 1953).

Measurements were made of the diffraction patterns of circular apertures from 0·2 to 1·0 wavelength in diameter when a plane polarized electromagnetic wave was incident normally upon them. Microwaves of wavelengths 16 cm and 32 cm were employed. The intensity of radiation relative to that of the unperturbed beam was determined at points along the electric and magnetic diameters of the apertures. The data disagreed with calculations from Young's Circuital Form in two major ways: (1) A sharp increase in intensity was observed at the ends of the electric diameter, (2) a surprising peak in intensity at the centres of apertures near one-half wavelength in diameter was 50% greater than calculations from the integral. A more complete interpretation of Young's theory of diffraction would include multiple reflections from the edges. The high intensity at the centre of the aperture a half-wavelength in diameter was qualitatively accounted for by multiple reflections from the edges near the ends of the magnetic diameter. A.

538.566 : 621.392.26

2566. An investigation of the characteristics of cylindrical surface waves. H. M. BARLOW AND A. E. KARBOWIAK. *Instn Elect. Engrs Paper* 1462, 8 *pp.* (1953).

Quantitative measurements on cylindrical surface waves were made at a frequency of ~10 000 Mc/s. For this purpose an axial standing-wave indicator and an instrument for determining the radial field distribution have been designed and tested by application to a wave of known configuration. The axial standing-wave indicator was used for simple impedance measurements and is now established as a practical device. Quantitative observations on cylindrical surface waves were made with the instrument for examining the radial field distribution, which at a long distance (say 30 ft) from a launching horn, agrees with that expected from theory. In the case of thin bare copper wires and enamelled wires of small size the radial decay coefficient deduced from the field-distribution graph approximated closely to the value obtained from the Sommerfeld–Goubau theory. On the other hand, the field distribution in the vicinity of the horn was always considerably distorted by radiation from the horn. For accurate work in the limited space available, it was found necessary to dispense with the horn and set up a surface-wave resonator. This arrangement can yield the same information on field distribution, since the standing-wave and travelling-wave patterns are identical. The wavelength of the surface wave supported by the resonator at its resonant frequency was measured and the decay coefficient calculated. Measurements on No. 24 S.W.G. copper wire thickly coated with polythene showed that the corresponding values of the decay coefficient derived from the Goubau approximate theory were greatly in error. A curve relating the coating thickness with the measured decay coefficient was obtained and compared with the Goubau predictions. Later the assumptions made in the original theory were revised, and accurate curves displaying the dependence of the decay coefficient on the thickness of dielectric coating, wire diameter and frequency were computed. These curves agree with the experimental results. A.

538.566

2567. A classroom antenna experiment. C. M. ZIEMAN. *Amer. J. Phys.*, **21**, 97–8 (*Feb.*, 1953).

Describes equipment for studying aerial patterns without the use of cumbersome outdoor apparatus. Patterns for numerous arrays, in good agreement with theory, are readily obtained. Construction of arrays observed by students is encouraged. A.

538.566 : 621.396.671

2568. On the longitudinal radiation from dielectric aerials. J.-C. Simon and G. Weill. *C.R. Acad. Sci. [Paris]* **235**, 1379—81 (*Dec.* 1, 1952) *In French.*

In the case of dielectric aerials, the field at ∞ is related to the phase velocity of the field along the aerial. This enables the radiation pattern and the total energy radiated to be simply calculated.

G. D. SIMS

538.566.2

2569. On the propagation of the wavefront in dispersive media. M. Marziani. *R.C. Accad. Naz. Lincei*, **12**, 683–7 (*June*, 1952) *In Italian.*

Sommerfeld's law that the wavefront propagates with a velocity equal to the phase velocity of the wave of infinite frequency is derived, for the case of a homogeneous medium, by considering the dispersive properties as hereditary properties and applying a Laplace transformation. L. PINCHERLE

538.566.2

2570. On the propagation of the wavefront in heterogeneous dispersive media. M. Marziani. *R.C. Accad. Naz. Lincei*, **13**, 127–31 (*Sept.–Oct.*, 1952) *In Italian.*

The wavefront propagates with velocity $(\varepsilon(z)\mu)^{-1/2}$ for a plane wave perpendicular to the z-axis. An integral expression is also given for the electric field in the neighbourhood of the wavefront.

L. PINCHERLE

538.566.2 : 621.396.11

2571. The effect of particle shape and composition on microwave attenuation and scattering by precipitation. J. S. Marshall, T. W. R. East, K. L. S. Gunn and W. Hitschfeld. *Trans Inst. Radio Engrs Prof. Group on Antennas and Propagation, No.* 3, 180–5 (*Aug.*, 1952).

Plane electromagnetic waves travelling through air containing precipitation are attenuated by the particles of ice, snow, or water. Ice particles scatter some of the radiation in all directions, but in the cm-wave band they do this without absorbing any of it, since ice is very nearly a perfect dielectric. Water, on the other hand, has considerable dielectric absorption and a large part of the attenuation by rain is due to thermal dissipation. A.

538.566.2 : 621.396.11

2572. Tropospheric wave propagation in a duct of non-uniform height. H. G. Hay and R. S. Unwin. *Proc. Phys. Soc.* [*London*] *B*, **65**, 981–9 (*Dec.*, 1952).

Describes an approximate method for extending the simple mode theory of tropospheric refraction (Booker and Walkinshaw, 1947) to cover situations where the refractive index profile varies with range. The transmission path is divided into a number of zones, in each of which the variation in the refractive index profile is small. In each zone the profile is then taken to be independent of range, and given by the mean profile throughout the zone. The duct-width d and the lapse-rate of modified refractive index at infinite height κ_∞ are found for each zone and are used, together with published propagation curves, to evaluate the distribution of radio field strength in the region beyond the horizon of a transmitter. Although the method is a general one, the final formula refers specifically to situations in which the field can be adequately described by the first mode alone, and where the mean profile of refractive index in each zone may be represented analytically by a one-half power law curve. An example of the application of the method to a practical situation is given. This shows good agreement between experiment and theory, and demonstrates the significant effect of changes in the refractive index profile on the level of field strength. The limitations of the method are pointed out, and its extension to cover other types of refractive index profile and higher order modes is outlined. A.

538.566.3

2573. Theoretical resonance curves of interaction between electromagnetic waves, for vertical incidence in the ionosphere. M. Motzo. *Nuovo Cimento*, **9**, 213–19 (*March*, 1952) *In Italian.*

The theory of gyrointeraction has been here extended to the case of vertical incidence, having some experimental evidence of the possibility of obtaining gyrointeraction also with vertically incident waves. The resonance curves which were obtained are shown and it is evident that only one type of curve (with one maximum) is obtained in this case. A.

538.566.3 : 621.396.11

2574. The reflection and absorption of radio waves in the ionosphere. W. R. Piggott. *Proc. Instn Elect. Engrs, III*, **100**, 61–72 (*March*, 1953).

A brief historical review is given of investigations made in the United Kingdom since 1935 together with a detailed discussion of the factors which must be considered when making accurate measurements of this phenomenon. An outline of the theory of ionospheric absorption and its application to practical absorption measurements is included. The effects of double refraction, polarization, spatial attenuation, dispersion, ionospheric inhomogeneities and partial reflection, which modify the apparent attenuation of radio waves reflected in the ionosphere, are discussed. The methods used to minimize errors due to these factors are presented in detail. The experimental techniques used in the routine absorption measurements are described fully. A.

538.566.3 : 621.396.11

2575. A review of present knowledge of the ionospheric propagation of very-low, low- and medium-frequency waves. F. A. Kitchen, B. G. Pressey and K. W. Tremellen. *Proc. Instn Elect. Engrs, III*, **100**, 100–8 (*March*, 1953).

Deals with the ionospheric propagation of waves of frequencies < 3 Mc/s and is confined mainly to transmission over medium and long distances (> 500 km). The results of investigations on low and very-low frequencies (< 300 kc/s) are summarized under the headings of field strength, phase and polarization measurement, the effects of ionospheric disturbances, the study of local ionospheric characteristics and theoretical studies. Only work done since 1937 is considered. An important item of the recent work is the study of ionospheric cross-modulation. A.

MAGNETIC EFFECTS 538.6

538.613

2576. A sensitive photoelectric method for measuring the Faraday effect. L. R. INGERSOLL AND W. L. JAMES. *Rev. sci. Instrum.*, **24**, 23–5 (*Jan.*, 1953).

A photoelectric method of measuring magneto-optic rotations as small as 1″ is described. This employs an optical system whereby light from a tungsten lamp traverses two double-image prisms and is focused by a series of concave mirrors on two 929 phototubes, after passing through a rotating polaroid chopper. The apparatus is now being used in an investigation of the Faraday effect in gases and vapours. A.

538.614

2577. Theory of the microwave permeability tensor and Faraday effect in nonsaturated ferromagnetic materials. G. T. RADO. Letter in *Phys. Rev.*, **89**, 529 (*Jan.* 15, 1953).

It is shown that under certain conditions the angle of rotation is proportional to the static intensity of magnetization at all points of the hysteresis loop. Previous related work [Abstr. 6329 (1951), 2854 (1952)] deriving this result assumed implicitly that the material is magnetically saturated. E. P. WOHLFARTH

538.652 : 548.0

2578. Measurement of magnetostriction in single crystals. R. M. BOZORTH AND R. W. HAMMING. *Phys. Rev.*, **89**, 865–9 (*Feb.* 15, 1953).

A simplified procedure is given for determining the 5 magnetostriction constants of a single crystal of a ferromagnetic cubic crystal. The crystal is cut as a disk parallel to a (110) plane, and strain gauges are cemented to the surfaces to measure strains in [001] and [111] directions. A magnetic field sufficient for saturation is oriented in 10° steps at various angles to the [001] direction, and magnetostriction is measured over a 90° range for each gauge. Each of the 18 data is then multiplied by suitable numbers, obtained by inversion of the strain matrix, to give the constants $h_1 \ldots h_5$. The method is applied to a crystal of a 78% Ni–Fe alloy to determine the magnetostriction associated with spontaneous magnetization in the [111] direction: $\lambda_{111} = 2h_2/3 + 2h_5/9$, a quantity important in the "Permalloy problem." The constants are also determined for a single crystal of Ni. A.

538.652

2579. Magnetic crystal anisotropy and magnetostriction of iron–nickel alloys. R. M. BOZORTH AND J. G. WALKER. *Phys. Rev.*, **89**, 624–8 (*Feb.* 1, 1953).

Single crystals of a number of alloys were prepared, and measurements made of the magnetic crystal anisotropy, and of the magnetostriction at saturation in different crystallographic directions, as dependent on the rate of cooling of the specimens after annealing. There is a large effect of the cooling rate on the anisotropy, for compositions near $FeNi_3$, where atomic ordering occurs. There is a definite but smaller effect of cooling rate on the magnetostriction. The composition for highest initial and maximum permeabilities is nearly that for which λ_{111}, the magnetostriction in the direction of easy magnetization, is equal to zero. A.

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

2580. Interaction of electrons with lattice vibrations. H. FRÖHLICH. *Proc. Roy. Soc. A*, **215**, 291–8 (*Dec.* 5, 1952).

Using methods of modern field theories a canonical transformation of the Hamiltonian of free electrons in the field of the lattice vibrations is performed. This transformation takes account of the bulk of the interaction of the electrons with the vibrational field and leads to a renormalization of the velocity of sound and of the interaction parameter F. An objection of Wentzel's against the use of large F is removed in this way. Even in the case of weak interaction the transformed Hamiltonian contains already in zero order terms which require a modification of the usual procedure in the theory of metals, and which at low temperatures lead to an increase of the effective mass of the electrons. Treatment of strong interaction requires the development of a new method. A.

539.11

2581. The cohesive properties of aluminium. R. GÁSPÁR. *Acta phys. Hungar.*, **2**, *No.* 1, 31–46 (1952) *In German.*

The method developed by Gombás [see Abstr. 1918 (1946)] to account for the cohesive properties of the alkali and alkaline earth metals is extended to the case of metals having valency greater than 2, and used to compute the lattice energy, lattice spacing, sublimation energy and compressibility of aluminium. The values obtained are found to agree with those observed. M. R. HOPKINS

539.11 : 536.63

2582. Note on the frequency spectra of simple solids from specific heat data. JENN LIN HWANG. Letter in *J. chem. Phys.*, **21**, 168–70 (*Jan.*, 1953).

Katz's method [Abstr. 4572 (1951)] for low temperatures has been extended to the whole temperature range. C. TURNER

539.11

2583. Atomic distribution in binary solid solutions. I. General theory. T. MURAKAMI. *J. Phys. Soc. Japan*, **7**, 549–54 (*Nov.–Dec.*, 1952).

Mayer's cluster method is developed in crystal statistics in analogous fashion to imperfect gases. The discussion is confined to two cases, one for two-phase separation and the other for order-disorder transition. These problems are treated just as the one-component imperfect gas, and the order parameters in the binary crystal are calculated in the same way as is used to obtain the radial distribution functions in imperfect gases by Montroll and Mayer. By means of the chain approximation, the expression for the pair distribution function is obtained in the closed form, somewhat like Zernike's formula. Also, the transition temperatures are identified with the temperatures at which singular points of the distribution function begin to appear. It seems, however, that

the results are no better than those obtained from Bethe's approximation. A.

539.11

2584. Atomic distribution in binary solid solutions. II. Modified theory for the case of nearly equal concentrations. T. MURAKAMI. *J. Phys. Soc. Japan*, **8**, 31–5 (*Jan.–Feb.*, 1953).

The method described in the preceding part is modified to treat *A* and *B* atoms equally. If the interactions are considered in appropriate manner, the present method gives the same critical temperature as those obtained from Bethe's approximation for most types of lattices. The exceptional cases are the critical temperatures of order-disorder transition in triangular and face-centred cubic lattices. The formulae to express the propagation of order in crystal lattices are obtained in closed forms. Also, for the cases of simple lattices, the formation of the superstructure is discussed. A.

539.11

2585. Atomic distribution in binary solid solutions. III. Diffuse scattering of X-rays by binary alloys. T. MURAKAMI. *J. Phys. Soc. Japan*, **8**, 36–40 (*Jan.–Feb.*, 1953).

The theory of diffuse scattering of X-rays by binary alloys is developed, based on the pair distribution functions of atoms which have been given in Pts I and II and which are entirely similar to those which appear in the theory of imperfect gases. These distribution functions allow of the theoretical calculation of the distribution of the diffuse intensity of scattered X-rays due to a short-range order at temperatures above the critical temperature, and the calculations are carried out both for the case of the order-disorder systems and for the two-phase separation systems. The disk-like shape of the diffuse maxima observed for Cu_3Au is predicted from this theory. It seems that this anomalous shape does not appear in the case of two-phase separation system. A.

MOLECULAR STRUCTURE 539.13

539.132

2586. On the numerical computation of polarization energy. J. I. HORVÁTH. *Acta phys. Hungar.*, **2**, *No.* 1, 47–53 (1952) *In German.*

The approximation method due to Gombás and Neugebauer (1934) is discussed for the case of a halogen–hydrogen molecule. An approximation for the improper integral occurring is derived. J. JACOBS

539.132

2587. On the wave-mechanical theory of the HCl molecule. Z. NÁRAY. *Acta phys. Hungar.*, **2**, *No.* 1, 55–65 (1952) *In German.*

A perturbation method is developed without appeal to empirical or semi-empirical parameters. The theory is based on the ionic model in which the molecular binding is due to 2 causes: attraction of different ionic point-charges, and polarization of the spherically symmetric electron distribution due to the proton. J. JACOBS

539.132

2588. Contribution to the W.K.B. method. P. URBAN. *Acta phys. Austriaca*, **6**, *No.* 2–3, 181–94 (1952) *In German.*

It is shown that odd approximations can be represented as total differentials and hence make no contribution to the quantum condition. Asymptotic expansions can be set up which avoid the Stokes phenomenon if the solutions of the differential equation are approximated by use of Bessel functions; in this expansion in turn the Bessel functions are replaced by their asymptotic series. J. JACOBS

539.132 : 548.7

2589. Localized functions in molecules and crystals. G. F. KOSTER. *Phys. Rev.*, **89**, 67–77 (*Jan.*, 1953).

The Wannier function in crystals is defined in terms of a differential equation and a variation procedure. This variation procedure is also used to define localized functions in molecules which can be used to build solutions of Schrödinger's equation. Illustrations of the procedure of building solutions of Schrödinger's equation from localized functions is given for examples taken from crystalline and molecular problems. Contact is made with Slater's work on the two-dimensional Mathieu problem. A numerical method of carrying out the variation procedure is discussed. A.

539.132

2590. On the group-theoretical treatment of the linear atomic chain. E. LEDINEGG AND P. URBAN. *Acta phys. Austriaca*, **6**, *No.* 1, 7–29 (1952) *In German.*

This is carried out for a rigid ring of identical monovalent atoms when exchange interaction between nearest neighbours only is considered. The binding energy in the ground state is calculated in detail for the case of 12 atoms by solving a 14-row secular determinant, thus extending the work of L. Hulthén, *Ark. Mat.*, **A 26**, *No.* 11 (1938). W. J. SWIATECKI

539.132

2591. Substituted methanes. X. Infrared spectral data, assignments, potential constants, and calculated thermodynamic properties for CF_3Br and CF_3I. P. R. MCGEE, F. F. CLEVELAND, A. G. MEISTER, C. E. DECKER AND S. I. MILLER. *J. chem. Phys.*, **21**, 242–6 (*Feb.*, 1953).

For Pt IX, see Abstr. 1804 (1953). Infrared wave numbers, relative intensities, and percent transmission curves have been obtained for CF_3Br and CF_3I in the region 400–2200 cm^{-1}. Assignments are given for the observed bands, in which the assignments of Plyler and Acquista for ν_2 and ν_3 are interchanged. Potential constants were calculated for both molecules by the Wilson *FG* matrix method. And, finally, the heat content, free energy, entropy, and heat capacity for the ideal gaseous state at 1 atmos pressure were calculated for 12 temperatures from 100° to 1000°K, using a rigid rotator, harmonic oscillator approximation. A.

539.132 : 535.343.2–15

2592. Infrared spectrum, molecular structure, and thermodynamic functions of hydroxylamine. P. A. GIGUÈRE AND I. D. LIU. *Canad. J. Chem.*, **30**, 948–62 (*Dec.*, 1952).

The absorption spectrum of pure hydroxylamine in the vapour and solid states was measured with a prism

instrument in the range 1·5–25 μ. Except in one case the fundamental vibrations were clearly outlined and in some instances, particularly the 1115 cm^{-1} band, the fine structure was resolved well enough for a significant calculation of the rotational constants. From the latter it was possible to confirm, within fairly close limits, the probable structure of the hydroxylamine molecule, a nearly symmetric top of point group C_s. At least two of the bands appeared to be doubled owing, presumably, to existence of a mixture of *cis*- and *trans*-forms of the molecule. The O–H and N–H distances have nearly the same value as in water and ammonia respectively and the N–O distance is 1·46 Å. The thermodynamic functions of gaseous hydroxylamine were calculated using the observed fundamental frequencies; some uncertainty accrues from the torsional oscillation. The infrared spectrum of crystalline hydroxylamine hydrochloride was also studied. A.

539.132

2593. The vibrational overlap integral and the intensities in band systems of diatomic molecules. T.-Y. Wu. *Proc. Phys. Soc.* [*London*] *A*, **65**, 965–72 (*Dec.*, 1952).

For the evaluation of the so-called vibrational overlap integral in the theory of the relative intensities in a band system of a diatomic molecule various approximate methods have been proposed for obtaining the vibrational wave functions. The "distorted wave" method of Gaydon, Pearse (1939) and Pillow (1949–51) is here discussed. For the case of Morse oscillators an approximate method is suggested that enables the integrals to be evaluated semi-analytically. The method is applied to the calculation of the relative intensities of the second negative bands of O_2^+ studied recently experimentally by Feast (1950). A procedure for applying the WKB method to find the vibrational wave functions of an anharmonic oscillator is also given. A general exact relation involving the vibrational wave functions of two electronic states and their potentials is given which may be used as a check for the accuracy of the approximate wave functions obtained by various methods. A.

539.132

2594. The Eckart conditions for a polyatomic molecule. S. M. Ferigle and A. Weber. *Amer. J. Phys.*, **21**, 102–7 (*Feb.*, 1953).

The Eckart conditions are introduced to insure the smallness of the interaction between vibration and rotation and define a system of co-ordinates in which the vibration of the atoms around their equilibrium positions is described. A.

539.132

2595. An infrared spectroscopic study of the carbonyl stretching frequency in a group of *ortho* and *para* quinones. M.-L. Josien, N. Fuson, J.-M. Lebas and T. M. Gregory. *J. chem. Phys.*, **21**, 331–40 (*Feb.*, 1953).

Reports on an experimental study of the C=O stretching vibration frequency in a large number of quinonoid compounds, both substituted and unsubstituted. For non-substituted *ortho* and *para* quinones, relationships between the carbonyl frequency and (*a*) the number of fused rings, (*b*) the oxidation-reduction potential, and (*c*) the index of free valence on the parent hydrocarbon are pointed out and discussed. It is shown that for a six-atom quinonoid ring the C=O frequency is, to a first approximation, a function of the C=O bond order. For substituted quinones, the variation in the carbonyl frequency is related to the induction effect of the substituent in the same way as is the variation in oxidation-reduction potential. Certain hydroxy-substituted quinones show spectral anomalies which do not seem to fit into the usual category of hydrogen bonded compounds. A.

539.132

2596. Spin splitting of $^5\Sigma$ and $^6\Sigma$ electronic states. K. Suryanarayana Rao. *Indian J. Phys.*, **26**, 47–53 (*Feb.*, 1952).

Expressions are derived for the rotational energy levels of $^5\Sigma$ and $^6\Sigma$ states adopting methods due to Van Vleck and Kramers. A.

539.132

2597. Effect of opposed disubstitution on intensities of even-even electronic transitions. H. McConnell. Letter in *J. chem. Phys.*, **20**, 1978 (*Dec.*, 1952).

In first approximation the absorption intensities of these forbidden transitions in centrally symmetric molecules are not altered. A small intensity change is caused by the perturbation of the electronic wave functions by nuclear vibration: this effect is discussed. L. PINCHERLE

539.132

2598. Pseudo-quadrupole effect for nuclei in molecules. N. F. Ramsey. Letter in *Phys. Rev.*, **89**, 527 (*Jan.* 15, 1953).

Additional terms arising from the low frequency diamagnetism and from electron spins are included to improve Foley's calculation [Abstr. 3604 (1947)]. D. H. WHIFFEN

539.132

2599. Some overlap integrals involving *d* orbitals. H. H. Jaffé. *J. chem. Phys.*, **21**, 258–63 (*Feb.*, 1953).

Formulae are presented for overlap integrals for overlap of $d\pi$ with $p\pi$ and $d\pi$ orbitals, and for $d\delta$ with $d\delta$ orbitals. Slater AO's were used throughout. Numerical tables for these integrals for a variety of values of the parameters ρ and τ are given. A.

539.133

2600. The molecular structure of B_4Cl_4. M. Atoji and W. N. Lipscomb. Letter in *J. chem. Phys.*, **21**, 172 (*Jan.*, 1953).

The molecule has symmetry D_{2d}–$\bar{4}2m$, four B–B distances are 1·73 Å, two are 1·70 Å, all B–Cl distances are 1·69 Å. The B–Cl bonds are single, the B–B bonds roughly 2/3. The boron arrangement is related to that of B_4H_{10}. C. TURNER

539.133 : 535.343.4–14

Microwave spectrum and structure of iodosilane. *See Abstr.* 2347

539.133 : 535.343–15

Microwave spectrum and structure of $C_8H_{13}Br$ and $C_8H_{13}Cl$. *See Abstr.* 2336

539.133

2601. The transformation properties of internal coordinates under covering operations. M. C. TOBIN. Letter in *J. chem. Phys.*, **20**, 1980 (*Dec.*, 1952).

In certain cases a covering operation sends the change in one internal co-ordinate of a molecular group into the negative of the change of an equivalent co-ordinate. Failure to recognize this may result in a symmetry co-ordinate being assigned to the wrong symmetry class. Rules are given. J. JACOBS

539.133

2602. The effects of interactions in real polymer chains. F. BUECHE. *J. chem. Phys.*, **21**, 205–8 (*Feb.*, 1953).

The effect of interactions between the segments of a polymer chain on the size of the molecule has been calculated. Two approaches have been used. The first is a direct probability calculation using an exponential interaction energy between segments. The second follows the original approach of Flory but solves the problem to a different approximation. Both methods lead to essential agreement with Flory's result for small and moderate interactions. A probable reason for the spurious results found by others is proposed. A.

539.133

2603. Electric dipole moments of several molecules from the Stark effect. S. N. GHOSH, R. TRAMBARULO AND W. GORDY. *J. chem. Phys.*, **21**, 308–10 (*Feb.*, 1953).

The following molecular electric dipole moments, in Debye units, have been obtained from the Stark effect of pure rotational spectra observed in the microwave region: $0{\cdot}234 \pm 0{\cdot}004$ for NF_3; $1{\cdot}03 \pm 0{\cdot}01$ for PF_3; $1{\cdot}77 \pm 0{\cdot}02$ for POF_3; $3{\cdot}00 \pm 0{\cdot}02$ for HCN; $3{\cdot}92 \pm 0{\cdot}06$ for CH_3CN; $3{\cdot}83 \pm 0{\cdot}06$ for CH_3NC; $1{\cdot}79 \pm 0{\cdot}02$ for CH_3F; $0{\cdot}75 \pm 0{\cdot}01$ for CH_3CCH; $1{\cdot}26 \pm 0{\cdot}01$ for SiF_3H. All values apply to the ground vibrational state. A.

ATOMIC STRUCTURE . NUCLEUS . ISOTOPES
539.15

539.152.1

2604. Energy levels of light nuclei. IV. F. AJZENBERG AND T. LAURITSEN. *Rev. mod. Phys.*, **24**, 321–402 (*Oct.*, 1952).

A review of work published up to August, 1952, replacing the previous compilation in Pt III [Abstr. 2911 (1951)]. Energy-level diagrams are discussed for nuclides from He^5 to the isotopes of neon.

A. O. STANESBY

539.152.1

2605. The statistical theory of the nucleus. I. P. GOMBÁS. *Acta phys. Hungar.*, **1**, *No.* 4, 329–90 (1952) *In German.*

Expressions for the densities of kinetic and interaction energies of a Fermi gas of nucleons are derived in first order of the interaction, assumed of the scalar Yukawa type. The Weizsäcker inhomogeneity correction to the kinetic energy and the electrostatic energy with exchange are included. Assuming the N and Z densities to be Gaussian functions of the radius the total energy is minimized with respect to scale. With an interaction range given by the π meson mass reasonable agreement with experimental radii, binding energies and the most stable Z is obtained by choosing an appropriate interaction strength. Some results with Gaussian or exponential interactions are given for comparison. W. J. SWIATECKI

539.152.1

2606. The statistical theory of the nucleus. II. P. GOMBÁS. *Acta phys. Hungar.*, **2**, *No.* 3, 223–46 (1952) *In German.*

A second approximation to the density distribution of neutrons and protons is obtained by using the energy density of Pt I (preceding abstract) but assuming a density of the type $e^{-(r^2/a^2)}(1 + br^2)$. It is found that b has a very small effect, the density remaining Gaussian over a wide range of A, even when neutron and proton densities are varied separately. W. J. SWIATECKI

539.152.1

2607. On the angular momentum distribution of the nucleons in a nucleus. P. GOMBÁS. *Acta phys. Hungar.*, **2**, *No.* 3, 247–59 (1952) *In German.*

By an argument analogous to Fermi's for atomic electrons, the numbers N and Z at which s, p, d, etc. nucleons first appear in a nucleus are deduced assuming Gaussian density distributions calculated by the author (preceding abstracts). General agreement with the shell model is obtained. This is not the case if a constant nucleon density is taken instead.

W. J. SWIATECKI

539.152.1

2608. On the meaning of the notion of a shell. Theoretical basis of the quasi-atomic model of the nucleus. R. DAUDEL. *C.R. Acad. Sci.* [*Paris*] **235**, 1375–7 (*Dec.* 1, 1952) *In French.*

See also Abstr. 2034 (1953). A wave function in the form of a Slater determinant implies spatial correlations between particles of the same spin. It is suggested that such correlations are capable of reconciling the single particle and liquid drop aspects of the nucleus. W. J. SWIATECKI

539.152.1

2609. Studies in *jj*-coupling. IV. The $g_{\frac{9}{2}}$-shell. B. H. FLOWERS. *Proc. Roy. Soc. A*, **215**, 398–403 (*Dec.* 5, 1952).

For Pt III, see Abstr. 1833 (1953). The work of the first three papers of this series is here extended to the configurations $g_{\frac{9}{2}}^n$ of like particles. Wave functions are obtained for three particles, and energy-level diagrams are plotted as functions of the range of the force for two and three particles. The $\frac{7}{2}$ level of seniority three is shown never to be the ground state; this result is in conflict with the experimental findings and suggests a breakdown in the *jj*-coupling approximation. A.

539.152.1

2610. The ground state of N^{14}. A. M. FEINGOLD. Letter in *Phys. Rev.*, **89**, 318 (*Jan.* 1, 1953).

Discusses difficulties of the suggestion [Abstr. 1910

(1950); see also Abstr. 547 (1951)] that the ground state of N^{14} is on almost pure $^3D_1$ state, and considers the assumption that it is predominantly a P state, $^3P_1$ or $^1P_1$. This also is not completely satisfactory.

A. O. STANESBY

539.152.1

2611. The excited states of the N^{13} nucleus. H. L. JACKSON AND A. I. GALONSKY. *Phys. Rev.*, **89**, 370–4 (*Jan.* 15, 1953).

The properties of the excited states of N^{13} were reinvestigated by applying dispersion theory to the $C^{12}(p,p)C^{12}$ differential cross-section reported in Abstr. 2688 (1953). The quantity and accuracy of the data were sufficient to permit extraction of the experimental S wave phase shift up to 1·4 MeV. The remainder of the data was fitted by successive readjustment of the level parameters. The present analysis corroborates the previous momentum and parity assignments but gives somewhat different values for the resonant energies and widths. The level assignments together with the revised widths and resonant energies are as follows: The 0·46 MeV scattering anomaly is due to a virtual ($j = 1/2$, +) level in the compound nucleus N^{13} with $E_r = 2{\cdot}369$ MeV and $\Gamma = 31$ keV. The 1·7 MeV scattering anomaly is the result of two virtual levels, a ($j = 3/2$, −) level with $E_r = 3{\cdot}511$ MeV and $\Gamma = 55$ keV and a ($j = 5/2$, +) level with $E_r = 3{\cdot}558$ MeV and $\Gamma = 61$ keV. E_r and Γ are calculated in the centre-of-mass system and E_r is measured from the ground state of N^{13}. These new values for E_r and Γ agree quite well with those obtained from the $C^{12}(p,\gamma)N^{13}$ reaction provided it is assumed that the ($j = 5/2$, +) level does not participate appreciably in the capture process. The values of the reduced widths of the levels indicate that the two even-parity levels arise mainly from single particle excitation, but that the odd-parity level involves appreciable excitation of the core. A.

539.152.1

2612. The uniform model of the nucleus. I. G. WEINBERG AND J. M. BLATT. *Amer. J. Phys.*, **21**, 124–38 (*Feb.*, 1953).

The evidence for Wigner's model (1937) is reexamined to see whether, in the light of data accumulated since it was proposed, the agreement between the predictions of the uniform model and experimental binding energies is sufficiently good to serve as an argument against the shell model. This is found not to be the case. The uniform model gives qualitative agreement with experiment, but the detailed quantitative agreement is only moderately good. This rather indifferent record must be compared with the excellent evidence for nuclear shell structure in the same region of mass numbers. Nevertheless, it is felt that the uniform model should not be abandoned altogether, but rather should be reinterpreted to apply to the "characteristic state" postulated by Hurwitz and Bethe, rather than to the ground state. No test of this hypothesis is possible until more is known experimentally about the level spectra of nuclei. In this connection a modified semi-empirical form is suggested for the density of nuclear levels as a function of excitation energy. A.

539.152.1 : 539.155

2613. The binding energies and masses of the nuclei A = 17 to A = 32. U. CAPPELLER. *Z. Naturforsch.*, **7a**, 573–9 (*Sept.*, 1952) *In German.*

Measured Q values from 77 reactions are used systematically to bridge the gaps between masses deduced by Ewald [Abstr. 8149 (1951)] from spectrographic determinations of many authors. An accuracy of about 50 keV in the absolute values results. W. J. SWIATECKI

539.152.2

2614. The nuclear spins of ^{99}Ru and ^{101}Ru. J. H. E. GRIFFITHS AND J. OWEN. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 951–2 (*Nov.*, 1952).

The paramagnetic resonance spectrum from a crystal of $Ru(NH_3)_6Cl_3$ diluted with the diamagnetic salt $Co(NH_3)_6Cl_3$ (Ru : Co ~ 1 : 200) was measured at a wavelength of 1·2 cm at 20°K. The hyperfine structure indicates that the nuclear spins of Ru^{101} and Ru^{99} are both 5/2, and that the ratio of their magnetic moments (101 : 99) is 1·09 ± 0·03.

A. O. STANESBY

539.152.2

2615. Nuclear spin of vanadium 50. J. M. BAKER AND B. BLEANEY. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 952–3 (*Nov.*, 1952).

The paramagnetic resonance spectrum from a crystal of $K_4V(CN)_6{,}3H_2O$ (with the V^{50} content enhanced to 20%) diluted with the diamagnetic salt $K_4Fe(CN)_6$, $3H_2O$, was measured at a wavelength of 1·3 cm. The nuclear spin of V^{50} is 6.

A. O. STANESBY

539.152.2

2616. Nuclear spin of $_{95}Am^{241}$. M. FRED AND F. S. TOMKINS. Letter in *Phys. Rev.*, **89**, 318 (*Jan.* 1, 1953).

Photographs of the hyperfine structure suggest $I = 5/2$ and an appreciable quadrupole moment.

W. J. SWIATECKI

539.152.2

2617. Nuclear magnetic resonance multiplets in liquids. H. S. GUTOWSKY, D. W. MCCALL AND C. P. SLICHTER. *J. chem. Phys.*, **21**, 279–92 (*Feb.*, 1953).

Multiple magnetic resonance lines have been observed for H^1, F^{19} and P^{31} nuclei in compounds such as PH_3, PF_3, $F_2PO(OH)$ and BrF_5, in the liquid state. The multiplets consisted of two to seven equally spaced narrow components, symmetrically placed about a central frequency, and with splittings from 0·02 to 0·8 gauss. These multiplets arise from a new variety of interaction among the nuclear moments in a molecule. Resonance lines were found to be multiple either when a nucleus interacted with a different species of nucleus or when there was interaction between nuclei of the same species with resonance frequencies separated by a chemical shift. No compounds exhibited multiplets attributable to interactions among structurally equivalent nuclei. Nor were multiplets caused by nuclei whose electric quadrupole moments were coupled to a direction fixed in the molecule. The number and relative intensities of the components of a multiplet were determined by the number and statistical weights of the

various nuclear spin orientations of the nuclei causing the splitting. In a given molecule, the ratio of the multiplet splittings of the two different resonance lines was inversely proportional to the ratio of the gyromagnetic ratios of the interacting nuclei. The splittings were independent of applied magnetic field at 4180 and 6365 gauss; they were independent of temperature over ranges from 55°C to −130°C. In PF_5, the one gas examined, the splitting of the doublet fluorine resonance was the same in the gas and liquid phases; also, the doublet was demonstrated to arise from coupling with the phosphorus nucleus, rather than from a chemical shift between the resonances from the apex and meridian fluorines in the bipyramidal structure, as proposed earlier. All of the above characteristics are accounted for theoretically by assuming the magnetic nuclei interact via magnetic fields inside the molecule. The qualitative aspects are predicted by coupling of the form $A_{12}\mu_1 \cdot \mu_2$ between the nuclear moments μ_1 and μ_2. The coupling constant A_{12} depends upon the detailed mechanism, which must involve the molecular electrons. Second-order perturbation theory was used to calculate the relative magnitudes of coupling via the electron orbital and the electron spin magnetic moments. The electron spin mechanism was found to give splittings ten to twenty times the orbital. Approximate calculation of the electron spin mechanism in several simpler cases gave good agreement with experiment. The influence upon the splittings of electric quadrupole coupling and spin-lattice relaxation was considered and is discussed briefly. A.

539.152.2

2618. Nuclear gyromagnetic ratios. IV. Yu Ting and D. Williams. *Phys. Rev.*, **89**, 595–6 (*Feb.* 1, 1953).

For Pt III, see Abstr. 7185 (1951). The superregenerative oscillator techniques described in earlier reports have been employed to observe nuclear magnetic resonance absorption by B^{10}, N^{14}, Cl^{35}, Cl^{37}, As^{75}, In^{113}, In^{115} and Bi^{209}. Nuclear g factors and magnetic moments of these nuclei are tabulated for comparison with corresponding values obtained by other techniques. A.

539.152.2

2619. The dynamical theory of nuclear induction. R. K. Wangsness and F. Bloch. *Phys. Rev.*, **89**, 728–39 (*Feb.* 15, 1953).

Starting from the microscopic viewpoint, the dynamics of nuclear induction is derived by means of statistical methods. The only essential lack of generality lies in the assumption that the nuclei in the sample are independent of each other, so that the treatment does not account for features arising from spin-spin interaction. By considering the simultaneous action of an arbitrary external field and of the molecular surroundings upon a representative nucleus a system of linear differential equations of the first order is derived for the "distribution matrix." It is analogous to the classical Boltzmann equation for the distribution function and allows, upon integration, to determine the macroscopic average value of any spin function in its dependence upon time. This general result is particularly applied to the time dependence of the macroscopic nuclear polarization, and the conditions are investigated under which it satisfies the phenomenological differential equation originally proposed by one of the authors (F.B.). Besides the fact that this equation does not describe line structures caused by the interaction of neighbouring spins its validity is found to be seriously restricted only for nuclei having a spin larger than unity and in cases where, in addition, quadrupole relaxation is essential. It demands in these cases that the molecular surroundings are isotropic, e.g. as in gaseous and liquid samples, and further, that their characteristic frequencies of interaction with the nuclei are large compared to the Larmor frequency so that there exists equality between the longitudinal and the transverse relaxation time. A.

539.152.2

2620. Deviations from *LS* coupling in the spheroidal core nuclear model. J. P. Davidson and E. Feenberg. *Phys. Rev.*, **89**, 856–63 (*Feb.* 15, 1953).

Deviations of measured magnetic moments from the Schmidt limits have been interpreted in terms of a failure of *LS* coupling. The model of an odd nucleon coupled to a non-spherical core provides an unforced theoretical basis for this interpretation. Projection operators for pure *LS* coupling states are introduced and applied to compute the statistical weights of the $L = I - \frac{1}{2}$ and $L' = I + \frac{1}{2}$ components in Bohr's strong coupling wave function. The orbital gyromagnetic ratio of each component is also determined. Numerical results on the energy displacements produced by the coupling of the odd nucleon to the distorted core are generally unfavourable to the strong coupling description. A perturbation method appropriate to a weak coupling description is more likely to provide a satisfactory solution of the dynamical problem. A.

539.152.2 : 539.153

2621. The ground state hyperfine structure and nuclear magnetic moment of praseodymium. Hin Lew. Letter in *Phys. Rev.*, **89**, 530 (*Jan.* 15, 1953).

Atomic beam magnetic resonance measurements indicates a $^4I_{9/2}$ ground state with $4f^36s^2$ configuration for Pr; $\mu = +3{\cdot}8$ nm assuming spin 5/2.

D. H. Whiffen

539.153

2622. Note on the atom form factor calculated from the Thomas–Fermi model. K. Umeda. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 57–9 (*Feb.*, 1951).

Using the Rozental approximate formula for the Thomas–Fermi function, the dependence of the atom form factor of the TF atom on atomic number as well as on $(\sin\theta)/\lambda$ was expressed in closed form by an elementary function. A.

539.153

2623. The mean excitation energy of the Thomas–Fermi–Dirac atom. K. Umeda. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 60–4 (*Feb.*, 1951).

As a test of the validity of the Thomas–Fermi–Dirac atom the mean excitation energy of the neutral atom was calculated as a function of the atomic number, using the recently published table of the TFD function. The TFD atom did not much improve the agreement with experimental values in comparison to the TF atom. A.

539.153

2624. Detection of the magnetic resonance of excited atomic levels. Structure of the 6^3P_1 level of the mercury atom. J. BROSSEL. *Ann. Phys.* [*Paris*] **7**, 622–54 (*Sept.–Oct.*, 1952) *In French.*

Detection was achieved by means of the intensity changes of the π and σ components at magnetic resonance. A theory is given of the shape of the resonance line, which is in detailed agreement with experiment. The life-time of the 6^3P_1 level was measured for all the Hg isotopes, and the Landé factor for even isotopes. The structure of the level was completely elucidated and an experimental verification obtained of the Rabi–Maiorana formulae.

L. PINCHERLE

539.153

2625. On an analytic approximation procedure for the determination of eigenfunctions and energy eigenvalues of atomic electrons. I. R. GÁSPÁR. *Acta phys. Hungar.*, **2**, *No.* 2, 151–70 (1952) *In German.*

Approximate single particle solutions are found in a potential resembling closely the universal potential of the Thomas–Fermi atom. The corresponding energies for 1*s*, 2*p*, 3*d*, 4*f* electrons agree well with experiment and "self-consistent field" calculations.

W. J. SWIATECKI

539.153

2626. The spectrum of discrete eigenvalues in a negative atomic ion. T.-Y. WU. *Phys. Rev.*, **89**, 629–30 (*Feb.* 1, 1953).

It is pointed out that the usual argument for a finite number of stable discrete states in a negative atomic ion is not conclusive, and it is suggested that the question whether there are infinitely many discrete states in a negative ion, of hydrogen for example, calls for an investigation of the behaviour of the spectrum of eigenvalues of the Hamiltonian for a two-electron atomic system at the point $Z = 1$. A.

539.154 : 537.533.72

A new determination of $h/\sqrt{(em_0)}$ by electron diffraction. *See Abstr.* 2485

539.155.2

2627. The chemical isotope separation method [treated] as a rectification problem. E. W. BECKER AND K. BIER. *Z. Naturforsch.*, **7a**, 651–64 (*Oct.*, 1952) *In German.*

The optimum running conditions of single and multistage chemical exchange columns and the starting up times are calculated with particular reference to the enrichment of C^{13} by the reaction $HC^{12}N + C^{13}N^- \rightleftarrows HC^{13}N + C^{12}N^-$. The dependence of the separative properties on throughput, gas pressure and column diameter is determined experimentally. It was found that the enrichment factor in columns packed with glass helices is considerably enhanced by a preliminary treatment with suitable wetting agents and that the addition of such agents to the NaOH feed does not impair the exchange rate, which is accordingly not controlled by interface processes. Design data are given for a 4-stage plant of an output of 0·18 mol carbon/day containing 12% C^{13} (see also abstract following). H. LONDON

539.155.2

2628. Performance of a chemical exchange plant for the enrichment of C^{13}. E. W. BECKER, K. BIER, S. SCHOLZ AND W. VOGELL. *Z. Naturforsch.*, **7a**, 664–8 (*Oct.*, 1952) *In German.*

A continuously operating plant based on the design data given in the preceding abstract is described in detail. It consists of 6 columns of 2·6 m length. The first 3 represent one stage each, the next two columns form the 4th stage. In the last column and in the upper part of the fifth the final conversion of HCN into NaCN takes place. By inserting a suitable capillary into the HCN stream between the last two columns and by controlling the production rate of HCN by the gas pressure in the first column, this rate is automatically balanced against the supply of NaOH, which is added at the heads of the first three stages and of the last column. The output is 0·16 mol carbon/day at a C^{13} concentration of 12%. This concentration is reached after a starting up time of 53 hr. H. LONDON

539.155.2

2629. Isotope enrichment by the photoexcitation of specific isotopes. C. C. MCDONALD AND H. E. GUNNING. Letter in *J. chem. Phys.*, **20**, 1817 (*Nov.*, 1952).

Dried air presaturated with mercury vapour was allowed to flow through a long quartz tube irradiated near the downstream end by means of a Hg^{198} discharge tube. After six 10-hour runs the HgO deposited upstream from the irradiated zone had the following isotopic composition (normal values in brackets): 196, 0·01 (0·15); 198, 0·16 (10·1); 199, 10·7 (17·0); 200, 18·2 (23·3); 201, 24·6 (13·2); 202, 14·3 (29·6); 204, 32·0 (6·7). L. PINCHERLE

539.155.2

2630. Variations in isotopic abundances of strontium. L. T. ALDRICH, L. F. HERZOG, W. K. HOLYK, F. B. WHITING AND L. H. AHRENS. *Phys. Rev.*, **89**, 631–2 (*Feb.* 1, 1953).

Isotopic abundances of mineral sources of Sr have been measured. Variations in the ratio Sr^{86}/Sr^{88} of unknown origin have been found from 0·1160 to 0·1220. In Rb free minerals, the variation of the ratio Sr^{87}/Sr^{88} (0·0832 to 0·0868) is small enough to be completely attributable to the decay of Rb^{87} in geologic time. The large Sr^{87}/Sr^{88} variation in Rb minerals (biotite) from 0·0840 to 0·2629 indicates their suitability for use in the determination of mineral age. A.

539.155.2 : 533.15

Thermal diffusion in isotopic mixtures in the critical region. *See Abstr.* 2251

539.155.4

2631. The mass difference of sulphur 32 and chlorine 35. A. FOLKIERSKI. *Proc. Phys. Soc.* [*London*] *A*, **65**, 1006–15 (*Dec.*, 1952).

The Q-values of the reactions $S^{32}(\alpha, p)Cl^{35}$ and $Cl^{35}(n, \alpha)P^{32}$ were measured as $-2{\cdot}02 \pm 0{\cdot}11$ MeV and $+1{\cdot}07 \pm 0{\cdot}15$ MeV respectively. From these Q-values and from the β-decay energy of P^{32} the difference in mass excess of S^{32} and Cl^{35} was calculated in two independent ways, giving $1{\cdot}96 \pm 0{\cdot}11$ MeV

and $1{\cdot}98 \pm 0{\cdot}15$ MeV. In the investigation of the (α, p) reaction the nuclear emulsion technique was used in conjunction with α-particles from ThC′. An ionization chamber was used to measure the α-particle energy in the case of the (n, α) reaction which was excited by fast neutrons obtained from the D–D process. A.

539.155.4

2632. The Zr^{92} — Mo^{92} and Zr^{94} — Mo^{94} pairs and the Zr^{96} — Mo^{96} — Ru^{96} triplet. J. S. GEIGER, B. G. HOGG, H. E. DUCKWORTH AND J. W. DEWDNEY. *Phys. Rev.*, **89**, 621–3 (*Feb.* 1, 1953).

Mass spectrographic measurements are reported of the following mass differences: $\frac{1}{2}W^{184}$ — Zr^{92}, $\frac{1}{2}W^{184}$ — Mo^{92}, $\frac{1}{2}Os^{188}$ — Zr^{94}, $\frac{1}{2}Os^{188}$ — Mo^{94}, $\frac{1}{2}Os^{192}$ — Zr^{96}, $\frac{1}{2}Os^{192}$ — Mo^{96} and $\frac{1}{2}Os^{192}$ — Ru^{96}. These results are used to check and supplement existing transmutation and disintegration data in the region of the Zr^{92} — Mo^{92} and Zr^{94} — Mo^{94} isobaric pairs and the Zr^{96} — Mo^{96} — Ru^{96} isobaric triplet. A.

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16

2633. Experimental nucleonics. E. BLEULER AND G. J. GOLDSMITH. *New York, Rinehart* (1952) 393 *pp.*

Review in *Science*, **117**, 87–8 (*Jan.* 23, 1953). "Covers a wide variety of techniques involving the measurement of radioactivity, from the determination of the decay scheme of K^{42} by coincidence measurements on the physical side, to separation of chemicals by solvent extraction on the chemical side."

539.16 : 614.898 : 621.398

2634. Remote control engineering. An introduction. H. L. HULL. *Nucleonics*, **10**, 34–5 (*Nov.*, 1952).

An introduction to a series of papers (abstracts following) outlining the work of the Argonne National Laboratory, Remote Control Engineering Division, on remote handling devices for manipulating highly radioactive materials behind shielding walls.

L. R. SHEPHERD

539.16 : 614.898 : 621.398

2635. Remote control engineering. Fundamentals of general-purpose remote manipulators. R. C. GOERTZ. *Nucleonics*, **10**, 36–43 (*Nov.*, 1952).

Early designs of remote manipulators employed hydraulic connection or electric-motor drive and 6 degrees of translational and rotational freedom and a motion for opening and closing a tongs. The requirements for general-purpose devices capable of performing many different manipulations with ease, speed and accuracy are outlined. Two types of master-slave manipulator with direct mechanical connection are described very briefly. L. R. SHEPHERD

539.16 : 614.898 : 621—526 : 621.398

2636. Remote control engineering. A force-reflecting positional servomechanism. R. C. GOERTZ AND F. BEVILACQUA. *Nucleonics*, **10**, 43–5 (*Nov.*, 1952).

In a master-slave type of manipulator, in which electrical transmission is employed instead of direct mechanical connection, it is necessary for the system to be reversible so that force and movement at the output are reproduced at the input. The principle is illustrated with reference to the transmission of a rotary motion with torque and positional control.

L. R. SHEPHERD

539.16 : 614.898

2637. Remote control engineering. Design and construction of shielding windows. K. R. FERGUSON. *Nucleonics*, **10**, 46–51 (*Nov.*, 1952).

The requirements and performance of large viewing windows through radiation shields, are discussed. Attention is given to the use of glass tanks filled with water, concentrated zinc bromide solution or other dense liquids. The effect of irradiation on the light transmission of commercial glasses is considered.

L. R. SHEPHERD

539.16 : 614.898

2638. Remote control engineering. Coloration of optical glass by high-energy radiation. G. S. MONK. *Nucleonics*, **10**, 52–5 (*Nov.*, 1952).

The coloration of glass by radiation is assumed to be due to the displacement of electrons and their capture in "holes" to form colour centres. CeO_2 and Ce_2O_3 act as inhibitors of this process. Experiments in which various optical glasses were irradiated with Co^{60} γ-rays are described. The addition of small quantitities ($0{\cdot}25$ to $1{\cdot}5\%$) cerium oxide, produced a marked reduction in coloration. The use of plastic optical parts instead of glass is considered. Lucite appears to be 500–1000 times more resistant to coloration than ordinary glass. L. R. SHEPHERD

539.16.08

2639. The measurement of micro-microcurie amounts of radon by a scintillation counting method. J. BRYANT AND M. MICHAELIS. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. R.C.C./R.*26, 8 *pp.* (1952).

The problem of assaying micro-microcurie amounts of radon is considered with special reference to the measurement of radon content of exhaled breath samples from radium workers. An apparatus is described which uses a scintillation counting technique and which has the following advantages over previously-used methods: (i) The radon content of ordinary moist air samples may be measured without pre-treatment of the sample. (ii) The apparatus is robust and insensitive to mechanical shock, electrical interference and γ- or cosmic-ray background. (iii) A number of air samples may be measured in rapid succession by the use of separate sample chambers and one scintillation counting apparatus. The sensitivity of the equipment is such that a radon sample of 10^{-13} curies/litre approximately doubles the normal background counting rate. In addition to the assay of radon content of air, the apparatus may also be used for the measurement of radium content of solutions using a de-emanating technique. A.

539.16.08

2640. X-ray calibration of radiation survey meters, pocket chambers, and dosimeters. F. H. DAY. *Circ. Nat. Bur. Stand., No.* 507, 11 *pp.* (1951).

The responses of instruments of ionization-chamber and G.M. counter types to measured exposures or intensities have been studied for radiations generated

by applied X-ray tube potentials ranging from 30 to 1200 kV. The results of these studies indicate that instruments of a given type constructed by different manufacturers behave similarly in the 250 to 1200 kV range. However, marked discrepancies occur among instruments of the same type constructed by different manufacturers for radiations generated by potentials lower than 250 kV. These discrepancies are related to the atomic numbers of the wall materials that envelop the sensitive volumes of the instruments. A.

539.16.08

2641. Determination of the radioactivity of a pegmatite of Delianova by means of nuclear emulsions exposed to layers of pulverized and compressed rock and to thin sections. S. M. TAMBURINO AND A. STELLA. *Nuovo Cimento*, **9**, 253–68 (*March*, 1952) *In Italian.*

Measurement of the quantity of radioactive elements contained in a rock is made by exposing a nuclear emulsion to a layer of pulverized and compressed rock. Studying a pegmatite of Delianova (Reggio Calabria), a concentration of $2{\cdot}9\times10^{-5}$ g of U per gram of pegmatite has been measured. The identification of radioactive ores contained in the rock, and the approximate determination of their radioactivity, have been performed using polished thin sections. The main radioactive ores of this pegmatite are uraninite and torbernite. A.

539.16.08

2642. Aerial surveying for radioactive ground contamination. D. M. DAVIS, J. C. HART AND K. Z. MORGAN. *Nucleonics*, **10**, 75–9 (*Nov.*, 1952).

Experimental tests were carried out to determine the feasibility of using commercial radiation detectors carried in aircraft, to measure radioactive contamination of large ground areas. The tests employed up to 37 curies of Co^{60}, up to 720 curies of Ta^{182} and smaller sources of Cs^{137} and Na^{24}. It was found that a commercial halogen-filled G.M. counter satisfied the requirements, but it is considered that better results could be obtained with scintillation counters.

L. R. SHEPHERD

539.16.08

2643. Relation of film characteristics to X- and gamma-ray monitoring. G. M. CORNEY. *Nucleonics*, **10**, 84–6 (*Nov.*, 1952).

The influences of radiation quality and development procedure on the evaluation of dosage by the photographic film method, are illustrated by experimental results. Curves are given, showing the response of a particular type of film to heavily and lightly filtered X-rays, for various tube voltages from 20 to 2000 kV, and the effects of development time, temperature and exhaustion of the developer. L. R. SHEPHERD

539.16.08

2644. Assay of mixed radioisotopes. J. F. TATE AND E. S. WILLIAMS. *Nucleonics*, **10**, 47–51 (*Dec.*, 1952).

The analysis of samples containing two radioactive tracers, to determine the ratio of the quantities of the two isotopes, is discussed. It is assumed that the radiations from the sample are counted in two different circumstances (e.g. with and without an absorber) so that the relative counting rates for the two activities, are changed. The conditions for minimizing the error in the determined ratio are derived. The application of the method to the analysis of mixtures of Na^{24} and K^{42} using absorbers to discriminate between the different energy β-rays, is described. L. R. SHEPHERD

539.16.08

2645. Activation assaying for tantalum ores. G. G. EICHHOLZ. *Nucleonics*, **10**, 58–61 (*Dec.*, 1952).

Ta^{181} is the only isotope present in the Ta ores which has a large thermal neutron activation cross-section for the production of a long half-life, high-energy γ-ray emitter. This makes it possible to determine the amount of Ta present in its ores by the thermal neutron activation method. Some correction has to be made in the case of euxenite ores, to allow for long period fission-products from the U which is present. L. R. SHEPHERD

539.16.08

2646. Carbon-14 sample preparation and counting techniques. I. Gas counting methods. O. K. NEVILLE. *Atomics* [*London*] **3**, 309–16 (*Dec.*, 1952).

These methods give increased sensitivity, precision and flexibility. Various equipments used are described.

F. R. HOLT

539.162

2647. Method of time-free solutions for radioactive decay and radionuclide production. L. GOLD. *J. appl. Phys.*, **24**, 88–90 (*Jan.*, 1953).

A time-free recursion formula development for the classical radioactive decay leads to a distribution form of solution for both natural and artificial chains. A.

539.163

2648. A Li^9 disintegration in a photographic emulsion. W. F. FRY. Letter in *Phys. Rev.*, **89**, 325 (*Jan.* 1, 1953).

A small secondary "star" produced by a low-energy fragment from a meson-induced "star" has been analysed, and is probably due to the disintegration of Li^9. A. C. COATES

539.163.1

2649. The half-life of europium-152, 154. J. KASTNER. Letter in *Canad. J. Phys.*, **31**, 169 (*Jan.*, 1953).

The $\frac{1}{2}$-life of the mixture $Eu^{152,154}$ was determined over >200 days as $15{\cdot}6 \pm 1{\cdot}5$ yr; there are possible applications as a substitute for Co^{60} in the teletherapy of deep-seated cancer. A. O. STANESBY

539.163.1

2650. Lifetimes of nuclear isomers. S. A. MOSZKOWSKI. *Phys. Rev.*, **89**, 474–82 (*Jan.* 15, 1953).

Lifetimes of nuclear isomers for γ-transitions are calculated theoretically on the basis of various independent particle models; e.g. single proton, single neutron and states of several particles. The calculations of this paper are essentially restricted to the most common type of transition: viz. multipole order equal to spin change. The lifetime is expressed in terms of a matrix element, M, whose theoretical value depends on the particular model of the nucleus. Radial integrals are calculated numerically, assuming that the nuclear wave functions are given by single particle wave functions for a spherical square well.

Empirical values of M^2 can be deduced from measured isomeric lifetimes, corrected for internal conversion. An analysis of empirical M^2 for some γ transitions points to a number of regularities which, in general, speak in favour of an independent particle model. The regularities are the following: Empirical values of M^2 for $M4$ transitions are of order unity and show little scattering and no distinction between odd proton and odd neutron nuclei. The lack of scattering within each group of transitions is consistent with predictions of a single particle model. However, according to this model, one would expect odd proton nuclei to have lifetimes about half as large as odd neutron nuclei for the same transition energy, and also would expect lifetimes about 1/10 as large as found empirically. Empirical values of M^2 for $M4$ transitions appear to be larger for transitions in nuclei with nearly closed shells. According to an independent particle model, M^2 for $E3$ transitions of energy 100 keV should be of order 10^{-8} for single neutron transitions, and vanish for many-particle transitions, such as those between $p_{\frac{1}{2}}$ and 7/2 + states. The fact that empirical M^2 for $E3$ transitions are small can be interpreted as resulting from small deviations from an independent particle model. In fact, empirical M^2 for transitions between $p_{\frac{1}{2}}$ and 7/2 + states in odd-neutron nuclei appear to be smaller the more nearly the nucleus can be represented as a closed shell nucleus. The empirical value of M^2 for an $M1$ isomeric transition in Li^7 is slightly larger than expected according to an independent particle model. A graph of energy levels for a spherical square well potential is presented. A.

539.163.1

2651. Measurement of the half-lives of AcC″, Cu^{66}, Mg^{27}, Ti^{51}, Tl^{206}, and V^{52}. B. W. Sargent, L. Yaffe and A. P. Gray. *Canad. J. Phys.*, **31**, 235–49 (*Feb.*, 1953).

With the exception of AcC″, which was collected by recoil, the radionuclides were produced by irradiating "spec.-pure" metals or oxides with neutrons in the NRX reactor. The β-activities were measured by the rate of deflection of a quartz fibre in an electroscope of recent design. The residual activities were carefully analysed and eliminated from the main activities by subtraction. Half-lives were determined by the method of least squares. In the case of copper, the effect of the positrons and negatrons from Cu^{64} was suppressed with an aluminium absorber. The following values were found for the half-lives: AcC″, $4{\cdot}79 \pm 0{\cdot}02$; Cu^{66}, $5{\cdot}10 \pm 0{\cdot}02$; Mg^{27}, $9{\cdot}45 \pm 0{\cdot}04$; Ti^{50}, $5{\cdot}79 \pm 0{\cdot}03$; Tl^{206}, $4{\cdot}19 \pm 0{\cdot}02$; and V^{52}, $3{\cdot}76 \pm 0{\cdot}02$ min. The half-life found for Cu^{66} from the measurements with the electroscope was confirmed in some measurements with a proportional counter and scale of 1000. A.

539.163.2

2652. The radioactive decay of tellurium^{131}. K. Geiger. *Z. Naturforsch.*, **7a**, 579–83 (*Sept.*, 1952) *In German.*

Telluric acid was irradiated with thermal neutrons and the activity, enriched by a Szilard–Chalmers separation, revealed a $\frac{1}{2}$-life of $24{\cdot}8 \pm 0{\cdot}5$ min for Te^{131}. A new γ was found. Absorption and coincidence measurements show that the β-decay is complex. A decay scheme is deduced and compared with the shell model. W. J. Swiatecki

539.163.2

2653. Natural radioactivity of bismuth. W. Riezler and W. Porschen. Note in *Z. Naturforsch.*, **7a**, 634–5 (*Sept.*, 1952) *In German.*

Alpha-particle tracks of 9–11 μ length were obtained in Ilford C2 plates impregnated with 4% Bi ammonium citrate solution, dried and left 100 days in an inert atmosphere before development; the energy of the α-particles is 2·9 MeV, and the estimated $\frac{1}{2}$-life for Bi is $(2{\cdot}0 \pm 0{\cdot}8) \times 10^{17}$ yr. A. O. Stanesby

539.163.2

2654. ^{55}Cr, a new chromium isotope with a half-life of 3·52 min. A. Flammersfeld and W. Herr. *Z. Naturforsch.*, **7a**, 649–51 (*Oct.*, 1952) *In German.*

Cr^{55} was produced by the reactions $Cr(n, \gamma)$ and $Mn^{55}(n, p)$; it has a $\frac{1}{2}$-life of $3{\cdot}52 \pm 0{\cdot}03$ min, emitting β-rays with $E_{max} = 2{\cdot}85$ MeV, but no γ-rays. A. O. Stanesby

539.163.2

2655. The disintegration of radium D. A. A. Jaffe and S. G. Cohen. *Phys. Rev.*, **89**, 454–8 (*Jan.* 15, 1953).

The disintegration of radium D has been investigated using a gaseous source of lead tetramethyl in a proportional counter. The form of the low energy β-spectrum coincident with the 46·7 keV γ-ray has been determined. The end point has been found to be $15{\cdot}2 \pm 1$ keV. The shape of the spectrum shows good agreement with the Fermi theory for an allowed transition, in which the effect of screening on the Coulomb factor is neglected. The results indicate that the number of β-particles below 3 keV is somewhat less than that predicted by theory, neglecting screening. It is also concluded that the change in binding energy of the atomic electrons (about 10 keV) released in the decay, is included in the energy of disintegration of the β-particles, and is shared between the β-particle and neutrino. A.

539.163.2

2656. Radiations of 6·7-day U^{237}. F. Wagner, Jr., M. S. Freedman, D. W. Engelkemeir and J. R. Huizenga. *Phys. Rev.*, **89**, 502–7 (*Jan.* 15, 1953).

The radiations of U^{237} have been studied using a magnetic lens β-ray spectrometer and scintillation spectrometers for β's and γ's singly and in coincidence. A β with an end-point energy of 245 ± 5 keV was found along with evidence for the existence of a lower energy component; γ's of energy 27, 43, 59, 165, 207, 269, 334, 370 and 430 keV were found, and probably a γ of 102 keV. The decay scheme constructed gives a total decay energy for this isotope of 551 ± 5 keV. A.

539.163.2

2657. Gamma-radiations from Zr^{95} and Nb^{95}. C. E. Mandeville, E. Shapiro, R. I. Mendenhall, E. R. Zucker and G. L. Conklin. *Phys. Rev.*, **89**, 559–61 (*Feb.* 1, 1953).

By employing lead absorption, coincidence counting techniques and scintillation spectrometry, it has been shown that each β-ray of Nb^{95} is followed by a γ-ray of energy $0{\cdot}76 \pm 0{\cdot}02$ MeV and that most of the β-rays of the parent element Zr^{95}, are followed by

a single γ-ray at $0{\cdot}73 \pm 0{\cdot}02$ MeV. A disintegration scheme is proposed. A.

539.163.2

2658. Genetics of the Ge^{78}–As^{78} fission chain. N. SUGARMAN. *Phys. Rev.*, **89**, 570–2 (*Feb.* 1, 1953).

The half-life of Ge^{78}, measured by isolation of the $(91{\cdot}0 \pm 0{\cdot}6)$-min As^{78}, is $(86{\cdot}0 \pm 1{\cdot}0)$ min. No evidence for the ~40 min As reported in fission was found. The fission yields of Ge^{77}, As^{77}, Ge^{78} and As^{78} are reported. A.

539.163.2

2659. The isomer Rb^{84m}. R. S. CAIRD AND A. C. G. MITCHELL. *Phys. Rev.*, **89**, 573–4 (*Feb.* 1, 1953).

With the help of scintillation counters information on the isomer Rb^{34m} has been obtained. The isomer was produced by an $(n, 2n)$ bombardment of ordinary Rb salts. The half-life has been determined as 21 min. Three γ-rays have been observed at 0·239, 0·463 and 0·890 MeV. The last γ-ray occurs in the product Kr^{84}. Coincidence measurements show coincidences between the γ-ray at 0·239 MeV and another of nearly the same energy, while coincidences between the 0·463 and the γ-rays at 0·239 MeV are essentially negligible. A possible level scheme is discussed. A.

539.163.2

2660. Isomeric transitions in Tc^{93} and Tc^{96}. H. T. EASTERDAY AND H. A. MEDICUS. *Phys. Rev.*, **89**, 152–4 (*Feb.* 15, 1953).

The 390 keV γ-line reported to be associated with Tc^{92} is found to be Tc^{93} and is shown to be a $M4$ isomeric transition. Mass assignment to Tc^{96} is made for the isomeric transition previously known to have 34·4 keV energy and 51·5 min half-life, and a weak positron branching was found. A.

539.163.2

2661. The decay of Zn^{69}. R. B. DUFFIELD AND L. M. LANGER. *Phys. Rev.*, **89**, 854–5 (*Feb.* 15, 1953).

The 52 min ground state of Zn^{69} has been found to decay with a simple β-spectrum of end point $0{\cdot}897 \pm 0{\cdot}005$ MeV. The 13·8 hr isomer of Zn^{69} decays to the ground state by emission of a γ-ray of energy $0{\cdot}436 \pm 0{\cdot}004$ MeV. The conversion coefficient of this γ-ray is 0·06 indicating a $M4$ transition. A.

539.163.2 : 537.533.72

A description of a large double-focusing beta spectrometer and its application to a study of the decay of In^{114}. *See Abstr.* 2491

539.163.2 : 539.165

2662. Researches on short-lived β-radioactivity and nuclear isomerism. G. VENDRYÈS. *Ann. Phys.* [*Paris*] **7**, 655–709 (*Sept.–Oct.*, 1952) *In French.*

Using electron circuits to define periods of bombardment and observation (50 per sec) with a ~600 keV deuteron generator and systems of coincidence counters, the β-disintegrations of Li^8 and B^{12} were studied. The absorption limits are $6{\cdot}8 \pm 0{\cdot}4$ and $7{\cdot}2 \pm 0{\cdot}4$ g/cm² respectively. In the former $(2 \pm 1)\%$ disintegrations lead to a 4·9 MeV level of Be^8 and in the latter $(4 \pm 1)\%$ to a 4·45 MeV level of C^{12}. A modified arrangement was used to study isomers produced by fast neutrons from $Be^9(d, n)B^{10}$. A period $0{\cdot}82 \pm 0{\cdot}02$ sec was confirmed in $Pb^{(207)}$ and as a check the disintegration of He^6 from $Be^9(n, \alpha)He^6$ was found to have $\tau = 0{\cdot}84 \pm 0{\cdot}03$ sec. W. J. SWIATECKI

539.164

2663. Photo-alpha particles from silver and bromine irradiated with 70 MeV bremsstrahlung. C. H. MILLAR. *Canad. J. Phys.*, **31**, 262–6 (*Feb.*, 1953).

The energy spectrum of the α particles ejected from Ag and Br nuclei has been studied in a nuclear research emulsion irradiated with 70 MeV bremsstrahlung from the Queen's University synchrotron. The main feature of the observed spectrum is a broad group with a peak at about 11 MeV. Evidence for particles of energies less than 6 MeV is inconclusive. Calculations have been made on the basis of the nuclear evaporation theory and give a predicted spectrum which is consistent in shape and peak position with the observed results. A.

539.164.75

2664. Evaluation of alpha-particle absorption by filter paper. J. S. ALERCIO AND J. H. HARLEY. *Nucleonics*, **10**, 87 (*Nov.*, 1952).

Experimental results are given, showing the loss of counts due to absorption of the α-particles in filter papers upon which airborne uranium has been deposited. The loss results from the penetration of the uranium into the paper. A correction factor of 30% is recommended to allow for the counting loss in Whatman No. 41 papers. L. R. SHEPHERD

539.164.9 : 548.736.4

Alpha-radiation damage in zircon. *See Abstr.* 2828

539.165

2665. The continuous gamma-ray spectrum accompanying beta-decay. P. BOLGIANO, L. MADANSKY AND F. RASETTI. *Phys. Rev.*, **89**, 679–83 (*Feb.* 15, 1953).

The spectral distribution and absolute intensity of the internal bremsstrahlung emitted in β-decay was investigated in P^{32}, Y^{91} and RaE. The γ-radiation was detected by means of a NaI(Tl) crystal, phototube, linear amplifier and one-channel discriminator. Care was taken to avoid spurious effects, and corrections were made for several factors. Both the spectral distributions and the absolute intensities of the continua are in excellent agreement with theoretical predictions. The differences in the spectra due to allowed or forbidden types of the β-transition and to different forms of interaction are too small to be detected in these experiments. Observations on the angular correlation of the internal bremsstrahlung of β-emitters and on the internal bremsstrahlung emitted in K capture are also reported. A.

539.165

2666. Experimental energy and angular distributions of inner bremsstrahlung. T. B. NOVEY. *Phys. Rev.*, **89**, 672–8 (*Feb.* 15, 1953).

The spectra of the continuous radiation or inner bremsstrahlung emitted in the β-decay of P^{32} and RaE have been measured in the region of 20–250 keV with a NaI scintillation spectrometer. Comparison of the spectra on an absolute basis with the prediction of the theory shows good agreement. The angular correlation of the radiation with the emitting β-par-

ticles was also measured. The results are in excellent agreement with theoretical predictions. A.

539.166

2667. Variation of the Klein–Nishina differential cross section with gamma energy. D. W. S. Smout. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. EL/R*892, 3 *pp.* (1952).

Curves are given for the Klein–Nishina differential cross-section for a range of γ-ray energies. The values are compared with results obtained from a γ-ray scintillation spectrometer. A.

539.166

2668. Interpretation of isomeric transitions of electric quadrupole type. A. Bohr and B. R. Mottelson. Letter in *Phys. Rev.*, **89**, 316–17 (*Jan.* 1, 1953).

The short life-times of electric quadrupole transitions, as compared with nuclear shell model predictions, are interpreted satisfactorily in terms of the coupled single-particle motion and nuclear surface oscillations. A. O. STANESBY

539.166

2669. The probable existence of an $E3 + M4$ mixture in an isomeric transition. R. D. Hill and J. W. Mihelich. Letter in *Phys. Rev.*, **89**, 323–4 (*Jan.* 1, 1953).

Measurements on the *L*-subshell activation ratios in Os^{191m} and the relative thermal neutron activation cross-sections for the ground- and metastable states, favour a mixture of *E*3 (73%) and *M*4 radiations in the transition. A. O. STANESBY

539.166

2670. Neutron capture γ-rays from titanium, chromium, iron, nickel, and zinc. B. B. Kinsey and G. A. Bartholomew. *Phys. Rev.*, **89**, 375–85 (*Jan.* 15, 1953).

The neutron capture γ-rays emitted by the even-charge elements, from Ti to Zn, have been investigated with the aid of a pair spectrometer. Ti emits a very simple spectrum. Two strong γ-rays, $6{\cdot}756 \pm 0{\cdot}006$ and $6{\cdot}412 \pm 0{\cdot}006$ MeV, are produced by capture in Ti^{48}. Neither the direct transition to the ground state of Ti^{49}, nor the transitions to the ground states of Ti^{48} and Ti^{50} were detected. From Cr the γ-rays corresponded to transitions to the ground state ($9{\cdot}716 \pm 0{\cdot}007$ MeV) and to the first excited state ($8{\cdot}881 \pm 0{\cdot}007$ MeV) of Cr^{54} are prominent and have intensities of 13 and 35 photons per 100 captures in Cr^{53}. The direct transition to the ground state of Cr^{51} was not detected. The Fe spectrum is dominated by a strong γ-ray with the energy $7{\cdot}639 \pm 0{\cdot}004$ MeV resulting from neutron capture in Fe^{56}. This γ-ray is produced in the transition in Fe^{57} either to the ground state or to the excited state at 14 keV. Two weaker γ-rays with nearly equal energies close to 6 MeV are also produced in this isotope. The ground state γ-ray and the γ-rays leading to the first two excited states of Fe^{55} have been identified. Of these, the ground state γ-ray ($9{\cdot}298 \pm 0{\cdot}007$ MeV) is strong, about 50 photons per 100 captures in Fe^{54}. A part of the counting rate ascribed to this γ-ray, however, may be due to the γ-ray producing the first excited state of Fe^{58} in a direct transition. The ground state γ-ray in Fe^{58} ($10{\cdot}16 \pm 0{\cdot}04$ MeV) accounts for about 5% of all captures by Fe^{57}. The Ni spectrum contains an intense γ-ray with an energy of $8{\cdot}997 \pm 0{\cdot}005$ MeV, which is produced in 50% of the captures in Ni^{58}. Another prominent γ-ray at $8{\cdot}532 \pm 0{\cdot}008$ MeV may represent the transition to the ground state in Ni^{61}; if so, it accounts for some 80% of captures in Ni^{60}. From considerations of intensity, 5 of the remaining Ni γ-rays can be ascribed to transitions to excited states in Ni^{59}. In the spectrum of Zn, few discrete γ-rays can be discerned above a background of unresolved radiations. Of these, a very strong γ-ray, with an energy to $7{\cdot}876 \pm 0{\cdot}007$ MeV, probably producing directly the ground state of Zn^{65}, is emitted in 40% of neutron captures by Zn^{64}. A.

539.166

2671. Neutron capture γ-rays from scandium, vanadium, manganese, cobalt, and copper. G. A. Bartholomew and B. B. Kinsey. *Phys. Rev.*, **89**, 386–95 (*Jan.* 15, 1953).

The neutron capture γ-ray spectrum from Sc consists of an exceptionally large number of γ-rays, and those of highest energy are only partially resolved when the line width in the coincidence spectrum is 130 keV. The γ-ray corresponding to the direct transition to the ground state in Sc^{46} ($8{\cdot}85 \pm 0{\cdot}08$ MeV), if correctly identified, has an intensity of 0·3 photon per 100 captures. V produces several strong γ-rays with intensities of about 10 photons per 100 captures. Of these, the γ-ray with the highest energy, $7{\cdot}305 \pm 0{\cdot}007$ MeV, can be identified with the transition to the ground state of V^{52}. A group of partially resolved γ-rays with energies between 7·6 and 8·0 MeV are tentatively ascribed to capture in the rare isotope V^{50}. If this interpretation is correct, the isotopic capture cross-section of V^{50} probably lies between 40 and 400 barns. The transition to the ground state in V^{51} was not detected. In Mn the transition to the ground state ($7{\cdot}261 \pm 0{\cdot}006$ MeV) is stronger than any other γ-ray in the spectrum (12 photons per 100 captures). With a line width of 100 keV it is only partially resolved from another strong γ-ray with an energy of $7{\cdot}15 \pm 0{\cdot}02$ MeV. The remainder of the Mn spectrum is complex. From Co, about 6 γ-rays are produced each with intensities of the order of 5 photons per 100 captures. The γ-ray with the highest energy ($7{\cdot}486 \pm 0{\cdot}006$ MeV) may be identified with either the transition to the ground state or to the isomeric state at 59 keV. The Cu spectrum is dominated by the strong γ-ray producing the ground state in Cu^{64}. Its energy is $7{\cdot}914 \pm 0{\cdot}006$ MeV and its intensity is 24 photons per 100 captures in Cu^{63}. Another strong γ-ray at $7{\cdot}634 \pm 0{\cdot}006$ MeV may be the transition to the ground state of Cu^{66}. A.

539.166

2672. Nuclear gamma-rays from low energy proton proton bombardment of sodium, magnesium, and aluminium. H. Casson. *Phys. Rev.*, **89**, 809–20 (*Feb.* 15, 1953).

Gamma-rays produced by the resonance capture of 200–415 keV protons in Na, Mg and Al have been investigated with a single crystal NaI(Tl) scintillation spectrometer. Excited states in Mg^{24}, Al^{25}, Al^{27} and Si^{28} with energies above the ground state of 12 MeV, 2·5 MeV, 8·6 MeV and 12 MeV, respectively, were found to decay by cascade γ-emission. Direct

transitions to the ground state of Mg^{24}, Al^{27} and Si^{28} were not observed. Observed pulse-height distributions, location of observed peaks, identifiable γ-rays and their relative intensities are given. Decay schemes are proposed to account for the observed γ-rays of Al^{27}, Si^{28} and Al^{25}. They are found to involve energy levels which are in general agreement with levels found in (d, n) and (p, p) scattering experiments; in the case of Al^{25}, with levels found in the mirror nucleus Mg^{25}. An estimate is made of the absolute proton capture probability in the targets used. A.

539.166 : 537.542

2673. An automatic recording gamma-ray spectrometer. T. D. STRICKLER AND W. G. WADEY. *Rev. sci. Instrum.*, **24**, 13–16 (*Jan.*, 1953).

A scintillation spectrometer making use of a large NaI/TlI crystal mounted on an RCA 5819 photomultiplier tube has been constructed. It was designed for the high-efficiency counting of γ-rays in the energy range 0·5–1·5 MeV. Techniques used for crystal mounting and assembly of apparatus have proved very satisfactory for prolonged operation. Additional components have been provided for automatic recording of data. A.

539.166.74

2674. Coherent scattering of gamma-rays by bound electrons. G. E. BROWN AND J. B. WOODWARD. *Proc. Phys. Soc.* [*London*] A, **65**, 977–80 (*Dec.*, 1952).

The coherent scattering of high-energy γ-rays by bound electrons in light atoms is investigated. The bound intermediate states of the electron are expanded in terms of free states and potential scatterings. It is found that not only the zero-order term of this expansion, but also the first-order term, must be kept, and that the latter is actually the larger of the two for large momentum transfer. A.

539.166.74

2675. Compton scattering in a homogeneous magnetic field. H. ROBL. *Acta phys. Austriaca*, **6**, *No.* 1, 45–52 (1952) *In German.*

Theoretical. The calculation is carried out for direction of incident light perpendicular, and direction of scattered light parallel to the magnetic field. It is shown that the line corresponding to free electron scattering is broadened into a band of width (for $E \ll mc^2$) $E(2\hbar ceH)^{\frac{1}{2}}/mc^2$, where E is the energy of the incident photons. L. PINCHERLE

539.166.74

2676. The detection of polarized γ radiation by the Compton process. N. R. STEENBERG. *Canad. J. Phys.*, **31**, 204–9 (*Feb.*, 1953).

The general relationship between the polarization vector describing partially polarized γ radiation and the effects measurable by scattering experiments is presented. The results are applied to the radiation emitted by nuclei aligned at low temperatures and some experimental results are predicted. A.

539.166.83

2677. The measurement and interpretation of the K Auger intensities of Sn^{113}, Cs^{137}, and Au^{198}. C. D. BROYLES, D. A. THOMAS AND S. K. HAYNES. *Phys. Rev.*, **89**, 715–24 (*Feb.* 15, 1953).

Auger electron intensity measurements have been made on Cs^{137}, Au^{198} and Sn^{113} with a magnetic lens spectrometer which is briefly described. K Auger yields for Ba and Hg of 0·130 ± 0·007 and 0·056 ± 0·008, respectively, were obtained. The K Auger electrons were resolved into three groups, K–LL, K–LX and K–XY, according as two, one or no L electrons were involved. The ratios of the intensities of the latter two to the K–LL were found to be for In 0·417 ± 0·016 and 0·076 ± 0·008; for Ba 0·40 ± 0·04 and 0·08 ± 0·02. The measured ratio of K–LX to K–LL for Hg was 0·71 ± 0·15. The relationship of these results to theory is discussed. A summary of measurements of K fluorescence yield and K Auger line intensity ratios is given. The Auger spectrum from Au^{198} indicates that K capture to Pt^{198} cannot occur in more than 0·5% of the disintegrations. A crude estimate of the L to K capture ratio for Sn^{113} indicates that it is not abnormally high. A.

539.166.835

2678. The theory of the double Compton effect. F. MANDL AND T. H. R. SKYRME. *Proc. Roy. Soc. A*, **215**, 497–507 (*Dec.* 22, 1952).

Using the methods of Feynman, the exact expression is derived for the differential cross-section that two photons of given energy are emitted into given directions, as the result of an unpolarized γ-ray striking an electron at rest. The probability for this process contains an extra factor $e^2/\hbar c$ compared with ordinary Compton scattering. There is great preference for one soft and one hard photon to be emitted, rather than two photons of approximately equal energy. The hard photon is most likely to be ejected into a narrow cone in the forward direction and, as the bombarding energy increases, this cone becomes narrower. All these results were to be expected. However, the soft photon also has a considerable preference for small-angle scattering, and its angular distribution is not roughly isotropic as one might have expected. A.

539.166.835

2679. Pair creation in a homogeneous magnetic field. H. ROBL. *Acta phys. Austriaca*, **6**, *No.* 2–3, 105–18 (1952) *In German.*

Using exact solutions of Dirac's equation the cross-section for pair creation by light quanta at 90° to the field is calculated in lowest order perturbation theory. With laboratory field strengths σ becomes appreciable (in units 10^{-24} cm^2) only for $h\nu \gtrsim 10^{14}$ eV.

W. J. SWIATECKI

539.166.835

2680. Z-dependence of the pair production cross section at 1·33 and 2·62 MeV. I. E. DAYTON. *Phys. Rev.*, **89**, 544–51 (*Feb.* 1, 1953).

The Z-dependence of the pair production cross-section has been measured at 1·33 MeV for Al, Cu, Sn and Pb, and at 2·62 MeV for Be, C, Al, Cu, Sn and Pb. A target is used which is thick for the positrons produced in it but thin for the incident γ-ray beam. The positrons stop in the target and are detected by observing their annihilation radiation with two NaI(Tl) scintillation counters in coincidence. At both energies the Z-dependence of the cross-section is best represented by an equation of the form $aZ^2 + bZ^4$. If it is assumed that the Born approximation calculations of the cross-section give the correct value in the limit

of low Z, then in lead at 2·62 MeV the measured cross-section is 23% higher than the value calculated from the Born approximation, and 104% higher at 1·33 MeV. All these results are in good agreement with the exact numerical calculations of Jaeger and Hulme. The present measurement shows that near threshold the pair production cross-section in lead is considerably higher than the Born approximation calculation, whereas at energies between 17 MeV and 280 MeV the value has been measured to be 10% to 15% lower than that calculated from the Born approximation. The crossover appears to occur at around 6 MeV. A.

539.166.835

2681. Electron-positron annihilation in flight. S. A. Colgate and F. C. Gilbert. *Phys. Rev.*, **89**, 790–2 (*Feb.* 15, 1953).

The positron-electron annihilation cross-section has been measured for 50, 100 and 200 MeV incident positron energies. Three small proportional counters in a magnetic field determined the incident electron or positron momentum, and a large scintillation counter immediately behind the absorber indicated the disappearance of a particle. The positron annihilation cross-section was determined by subtracting the electron loss rate (due mainly to bremsstrahlung energy losses) from the positron loss rate. The cross-sections obtained at 50, 100 and 200 MeV were, respectively, $11·0 \pm 2·5$, $6·3 \pm 1·2$ and $3·7 \pm 0·6$ millibarns per electron in a Be absorber, in good agreement with Dirac's two-quantum annihilation cross-section. The presence of annihilation radiation was detected in coincidence with the disappearance of a positron within a small cone in the forward direction. A.

539.169 : 533.15

2682. Tracer diffusion in the ground in radioactive leak location. A. Gemant. *J. appl. Phys.*, **24**, 93–5 (*Jan.*, 1953).

The diffusion in the ground of a radioactive tracer gas, used for locating leaks in buried pipes, has been calculated, and the results are presented in the form of graphs. It is shown how the information can be used to obtain the amount of radioactivity needed in a test for both β-emitters (C-14 in carbon monoxide) and γ-emitters (Br-82 in methyl bromide). A.

539.169 : 621.389

2683. Radioactive thickness gage controls paper weight. G. J. Leighton. *Electronics*, **25**, 112–13 (*Dec.*, 1952).

Absorption of β- and γ-radiation is used to determine the thickness of paper in a mill. The measuring head consists of a radioactive source and an ionization chamber mounted on either end of a U-shaped tube with a 2 in. gap through which the sheet passes. On one arm of the tube is fitted a 3-stage d.c. amplifier, a second ionization chamber and a second radioactive source. The outputs from the two ionization chambers are balanced. The current from the detector chamber depends upon the weight of the paper sheet passing through the gap. The current from the balancing chamber is varied by increasing or decreasing the air gap between it and its source. The second source is mounted on a vernier mechanism with a calibrated dial so that for any thickness of paper, the balance point is indicated by the dial setting. The method of balancing compensates for the decay of the sources, and there is zero current in the input resistor normally so that changes of value due to temperature fluctuations do not cause drift. A. C. Whiffin

NUCLEAR REACTIONS 539.17

539.172

2684. The coupling of angular momenta in nuclear reactions. R. F. Christy. *Phys. Rev.*, **89**, 839–42 (*Feb.* 15, 1953).

Seven nuclear reactions have been examined where the angular distribution of reaction products depends on the type of coupling of angular momentum vectors in the nucleus. In six of the seven, the experimental angular distribution is consistent with the assumption of Russell–Saunders coupling in the nucleus. In three of the seven, the experiments are consistent with the assumption that the bombarding particle brings a definite j in the reaction. Neither assumption is sufficient to explain the result in one reaction $(B^{11} + P)$. A.

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 2528–30

539.172 : 539.172.3

2685. Nuclear disintegrations by slow negative μ-mesons and photons. J. M. B. Lang. *Proc. Phys. Soc.* [*London*] *A*, **65**, 995–1005 (*Dec.*, 1952).

The emission of particles from a nucleus following the capture of a negative μ-meson is discussed using evaporation theory. Assuming a reaction of the form $\mu^- + P \rightarrow N + \mu^0$, it is possible to calculate a distribution of nuclear excitation from which the mean probability of charged particle emission is evaluated. In the relation between excitation U and nuclear temperature τ the exponent of τ is given the values 2 and 3. The usual law $U = \lambda\tau^2$ is found to predict results for proton emission which are far less than those experimentally observed. In order to investigate this energy-temperature relationship, data from low energy photo-disintegration experiments ($U \simeq 20$ MeV) have been compared with theoretical values. Combination of the limited evidence available with very high energy data suggests a variation of excitation with the cube of the nuclear temperature. A.

539.172.11

2686. A test of the charge symmetry hypothesis: positive to negative pion production ratio obtained in bombarding carbon with alpha-particles and protons. H. W. Wilson and W. H. Barkas. *Phys. Rev.*, **89**, 758–9 (*Feb.* 15, 1953).

Employing an experimental procedure which eliminates residual errors in geometry, etc., the ratio was found to be $0·72 \pm 0·17$. The α-particle energy was 375 MeV and the meson energy was 15 MeV observed at 90° to the beam. Coulomb effects are expected to bring about a depression of the production ratio from unity of about this magnitude. The experimental result, therefore, provides support for the

charge symmetry hypothesis. As supplementary information, the same apparatus was used to measure the pion plus/minus ratio for 330 MeV protons incident on C. The ratio found was $5{\cdot}4 \pm 0{\cdot}8$. A.

539.172.13

2687. Some absolute determinations of proton-gamma resonances in the energy range below 500 keV. S. E. HUNT. *Proc. Phys. Soc.* [*London*] *A*, **65**, 982–91 (*Dec.*, 1952).

An electrostatic analyser of high accuracy has been used to measure and control the energy of a proton beam accelerated by an electrostatic generator. By using a deflecting angle of $\pi/2\sqrt{2}$ radians, a wide incident beam was focused on to a narrow exit slit. Target currents of 10 μA were obtained homogeneous in energy to one part in a thousand. The beam energies were also measured absolutely to this accuracy. The instrument was used to determine the energy of the $Li^7(p, \gamma)$ resonance, which was found to be $441{\cdot}5 \pm 0{\cdot}5$ keV with a half width of $12{\cdot}2 \pm 0{\cdot}5$ keV. The energies of two sharp resonances in fluorine were found to be $340{\cdot}4 \pm 0{\cdot}4$ and $483{\cdot}1 \pm 0{\cdot}5$ keV, with half widths $2{\cdot}9 \pm 0{\cdot}2$ keV and $2{\cdot}2 \pm 0{\cdot}2$ keV respectively. A.

539.172.13

2688. The $C^{12}(p, p)C^{12}$ differential cross section. H. L. JACKSON, A. I. GALONSKY, F. J. EPPLING, R. W. HILL, E. GOLDBERG AND J. R. CAMERON. *Phys. Rev.*, **89**, 365–9 (*Jan.* 15, 1953).

The $C^{12}(p, p)C^{12}$ differential cross-section has been observed at four scattering angles by using differentially pumped gas targets of propane and ethylene. The scattering angles employed were 106·4, 127·8, 148·9 and 169·2 degrees in the centre-of-mass system and the energy range covered extended from 0·4 to 4·3 MeV. These measurements show the angular behaviour of the previously discovered scattering anomalies at 0·46 and 1·7 MeV and give values of the absolute cross-section accurate to within 5%. A careful search in 3 and 6 keV steps failed to reveal any indication of any hitherto unknown scattering resonances within the energy range surveyed. A.

539.172.13

2689. Inelastic events induced by 32-MeV protons on helium. J. BENVENISTE AND B. CORK. *Phys. Rev.*, **89**, 422–9 (*Jan.* 15, 1953).

A study of inelastic events induced by the bombardment of helium nuclei with 32 MeV protons has been made. No low-energy group of protons has been found which would indicate the existence of an excited, heavy-particle stable state of the helium nucleus. The absence of a bump on the continuum of protons from the reactions: $p + He^4 \rightarrow He^3 + n + p'$, $p + He^4 \rightarrow H^3 + p'' + p'$, indicates a maximum cross-section of 0·1 mb/sterad at 45° c.m. for the production of a single excited helium level as high as 23·3 MeV above the ground state. Further, the observed rather flat shape of the continuum requires the existence of at least two levels of about 1 MeV half-width, separated by about 1 MeV. The angular variation of the differential cross-section for the production of deuterons from the reaction $p + He^4 \rightarrow He^3 + d$ has been measured. When the principle of detailed balancing is invoked, good agreement with the prediction of the theory of Butler is obtained for r_0 (range of nuclear forces plus radius of He^3 nucleus) = $4{\cdot}2 \times 10^{-13}$ cm. A.

539.172.13

2690. The angular distribution of gamma rays in the $C^{12}(p, p'\gamma)$ reaction. H. E. GOVE AND N. S. WALL. *Canad. J. Phys.*, **31**, 189–93 (*Feb.*, 1953).

Protons of 7·1 MeV energy from the MIT cyclotron have been used to investigate the angular distribution of γ-rays from the $C^{12}(p, p'\gamma)$ reaction with respect to the incoming proton beam. These γ-rays result from transitions between the first excited state of C^{12} at 4·45 MeV and the ground state. The resulting distribution can be fitted by the expansion $I(\theta) = 1 - 0{\cdot}31 \cos 4\theta$, which is consistent with an assignment of two for the angular momentum of the first excited state of C^{12}. A.

539.172.13 : 523.72

2691. The proton-proton reaction and energy production in the sun. E. A. FRIEMAN AND L. MOTZ. *Phys. Rev.*, **89**, 648–50 (*Feb.* 1, 1953).

The proton-proton capture cross-section is recalculated using the recently computed deuteron wave functions of Feshbach and Schwinger and the most recent value of the Fermi G factor. The energy production of the p-p cycle is redetermined and applied to the sun, using the luminosity calculations of Epstein. It is shown that the p-p cycle outweighs the carbon cycle by a considerable factor under the assumed conditions of temperature and density. A.

539.172.13

2692. Neutron energy distribution from the proton bombardment of Li, Be, and C at 375 MeV. W. F. GOODELL, JR, H. H. LOAR, R. P. DURBIN AND W. W. HAVENS, JR. *Phys. Rev.*, **89**, 724–7 (*Feb.* 15, 1953).

High energy neutrons were produced by bombarding Li, Be and C targets with protons having a maximum energy of 375 MeV. The energy spectrum of the neutrons emitted in the forward direction was measured by determining the range spectrum of recoil protons scattered at 45° by a polyethylene scatterer. A telescope of stilbene crystals with Cu range-determining absorbers was used as a detector. The neutron beam was monitored by a Bi fission ionization chamber. For elements studied, the width of the neutron energy distribution broadens and the energy of the peak of the distribution decreases as the atomic number of the target material increases. A.

539.172.13

2693. Electrostatic analysis of nuclear reaction energies. III. D. J. DONAHUE, K. W. JONES, M. T. MCELLISTREM AND H. T. RICHARDS. *Phys. Rev.*, **89**, 824–6 (*Feb.* 15, 1953).

For Pt II, see Abstr. 1111 (1953). Electrostatic analysis of incident and product particles has been used to measure the following reaction energies: $Na^{23}(p, \alpha)Ne^{20}$ ($2{\cdot}379 \pm 0{\cdot}003$ MeV); $Na^{23}(p, \alpha)Ne^{20*}$ ($0{\cdot}745 \pm 0{\cdot}002$); $Na^{23}(p, p')Na^{23*}$ ($-0{\cdot}439 \pm 0{\cdot}001$ MeV); $Mg^{24}(p, p')Mg^{24*}$ ($-1{\cdot}371 \pm 0{\cdot}002$ MeV); $Al^{27}(p, p')Al^{27*}$ ($-0{\cdot}843 \pm 0{\cdot}002$ MeV); $Al^{27}(p, \alpha)Mg^{24}$ ($1{\cdot}594 \pm 0{\cdot}002$ MeV); $Al^{27}(p, \alpha)Mg^{24*}$ ($0{\cdot}228 \pm 0{\cdot}003$ MeV). A.

539.172.13

2694. Spin-orbit coupling in the D-D reaction. R. J. Blin-Stoyle. *Proc. Phys. Soc.* [*London*] *A*, **65**, 949–50 (*Nov.*, 1952).

It is shown that the observed angular distributions and the proton polarization of ~30% at 300 keV [Abstr. 6073, 8456 (1952)] might both be accounted for either by spin-orbit coupling due to tensor forces alone or to a non-central $L \cdot S$ type force.

W. J. SWIATECKI

539.172.13

2695. Angular distribution of γ-radiation following a deuteron stripping reaction. G. R. Satchelor and J. A. Spiers. *Proc. Phys. Soc.* [*London*] *A*, **65**, 980–2 (*Dec.*, 1952).

Expressions are derived theoretically for the angular distribution of γ-radiation from a deuteron stripping reaction, measured in coincidence with a fixed direction of the emitted particle. A.

539.172.13

2696. The theory of the deuteron stripping reaction. R. Huby. *Proc. Roy. Soc. A*, **215**, 385–98 (*Dec. 5*, 1952).

The differential cross-section for deuteron stripping reactions at energies several million electron volts above the Coulomb barrier is calculated by a method which is essentially that of Butler as regards physical assumptions and line of argument, but which employs a different mathematical technique and notation at many points, for reasons of clarity and exactitude. The procedure is assimilated into the S-matrix formalism. The essence of the method is the smooth joining up of the wave function for the nucleon stripped off, and the derivative of this wave function, on the two sides of the surface of the target nucleus. The formula obtained is discussed, to show how the various factors arise from the successive physical stages by which the reaction proceeds. New features are (*a*) the cross-section is now given explicitly for the case in which the stripped nucleon is captured into a virtual state, as well as for the case of a bound state, as hitherto; (*b*) the factor determining the absolute magnitude of the cross-section is given explicitly in a form which would permit of estimates being made of it. A.

539.172.13

2697. Angular distributions of protons from the reaction $F^{19}(d,p)F^{20}$. D. A. Bromley, J. A. Bruner and H. W. Fulbright. *Phys. Rev.*, **89**, 396–8 (*Jan.* 15, 1953).

A Teflon (CF_2) target was bombarded with 3·6 MeV deuterons from the Rochester 26 in. cyclotron, and the angular distributions of the resulting proton groups were determined using an ionization chamber detector. The following table gives the angular momentum transfer (determined by comparison with the Butler curves) and the cross-sections corresponding to the indicated levels in F^{20}:

Ground state:	$l_n = 0$ and 2,	$\sigma = 0{\cdot}92 \pm 0{\cdot}18$ mb/sterad (at 45°);
0·65 MeV level:	$l_n = 2$,	$\sigma = 7{\cdot}15 \pm 1{\cdot}4$ mb/sterad (at 45°);
2·05 MeV level:	$l_n = 2$,	$\sigma < 8$ mb/sterad (at 45°);
3·49 and 3·53(?) MeV level:	$l_n = 0$,	$\sigma = 116 \pm 23$ mb/sterad (at 7°).

These F^{20} states were found to have even parity, and the ground state spin was determined to be 1. A.

539.173.13

2698. Magnetic analysis of the deuteron-beryllium reactions. R. W. Gelinas and S. S. Hanna. *Phys. Rev.*, **89**, 483–8 (*Jan.* 15, 1953).

The charged particle spectra from the deuteron bombardment of Be^9 have been analysed magnetically with a spectrograph employing a second order focus. Previously established transitions to states in Be^{10} and Li^7 were observed, and a careful search of the proton and α-spectra failed to disclose additional states in these nuclei, throughout the region explored. The excitation energy of the second excited state of Li^7 was determined as $4{\cdot}62 \pm 0{\cdot}02$ MeV. The transition to the broad first excited state of Be^8, as well as to the ground state, was revealed in the triton spectrum. α- and triton continua resulting from the three-particle disintegrations, $Be^9(d,\alpha)Li^{7**}(\alpha)t$ and $Be^9(d,t)Be^{8*}(\alpha)\alpha$, were also observed and examined in some detail. Other three-particle disintegrations appear improbable but cannot be definitely excluded, at the bombarding energies employed from 0·5 to 1·0 MeV. A.

539.172.13

2699. Magnetic analysis of the $Sr^{88}(d,p)Sr^{89}$ reaction. C. E. McFarland and F. B. Shull. *Phys. Rev.*, **89**, 489 (*Jan.* 15, 1953).

A magnetic analyser was used to study proton groups produced when a $SrCO_3$ target was bombarded with 10·43-MeV deuterons. Three excited states of Sr^{89} were found in addition to the ground state. The corresponding Q values are 4·33, 3·26, 2·26 and 1·79 MeV. A.

539.172.13

2700. Energy levels in lead and bismuth and nuclear shell structure. J. A. Harvey. *Canad. J. Phys.*, **31**, 278–94 (*Feb.*, 1953).

A bismuth target and lead targets enriched in Pb^{206}, Pb^{207} and Pb^{208} have been bombarded with 14-MeV deuterons from the M.I.T. cyclotron. Proton and triton spectra were measured with aluminium absorbers and a triple proportional counter. The spectra have been carefully analysed and resolved into a relatively small number of groups. The proton spectra from all four targets are very similar, except for the long range state groups from the Pb^{206} and Pb^{207} targets. A striking similarity also occurs among the triton spectra from the four targets. The simplicity in the spectra probably arises because we are dealing with residual nuclei with closed or nearly closed shells of 82 protons and 126 neutrons. The fact that a (d,p) reaction proceeds mainly by means of a stripping process, in which only the neutron enters the nucleus, suggests the possibility that the similarities can be explained by a single particle model of the nucleus. Moreover, the (d,t) reaction is principally a pickup process and thus the single-particle model is suggested again. Observed energy levels are compared with the known levels measured from radiative transitions. Aided by the angular momentum and parity assignments of some of these known levels, tentative assignments of angular

momentum and parity are made to many of the new levels from a strong spin-orbit coupling shell model. A.

539.172.13

2701. Levels of Al^{25} from the $Mg^{24}(d,n)Al^{25}$ reaction. E. GOLDBERG. *Phys. Rev.*, **89**, 760–5 (*Feb.* 15, 1953).

A 67 keV target of Mg^{24} was bombarded with 4·007 MeV deuterons, and the neutron groups from the $Mg^{24}(d,n)Al^{25}$ reaction were studied at seven different angles with Ilford C2 emulsions. The observed Q values are $+0·07 \pm 0·06$, $-0·38 \pm 0·06$, $-0·08 \pm 0·05$, $-1·74 \pm 0·04$, $(-1·87 \pm 0·04)$, $-2·44 \pm 0·04$, $-2·67 \pm 0·04$, $(-2·85 \pm 0·04)$ and $-3·04 \pm 0·03$ MeV. The neutron groups with the Q values $-2·44$, $-2·67$ and $-3·04$ MeV correspond to virtual states of Al^{25} which have previously been seen as $Mg^{24} + p$ resonances. From the Butler theory for the angular distribution of the stripped neutrons, the ground state of Al^{25} is described by $J = 3/2$ or $5/2$, even parity; the first excited state is $J = 1/2$, even parity, and the second excited state is likely to be $J = 3/2$ or $5/2$, even parity. The level structure of Al^{25} is compared to that of Mg^{25}. A.

539.172.13

2702. Cross section for the reaction $D(d,p)H^3$. C. F. COOK AND J. R. SMITH. *Phys. Rev.*, **89**, 785–6 (*Feb.* 15, 1953).

Cross-sections for the reaction $D(d,p)H^3$ have been measured between 50 and 100 keV, using thin targets of deuterium absorbed in zirconium. With the angular distribution data of Wenzel and Whaling [Abstr. 7341 (1952)], the total cross-sections have been calculated. The total cross-section at 100 keV is measured to be 14·8 millibarns. A gas target was used to determine the cross-section at 420 keV. The value obtained was 49·3 millibarns. A.

539.172.13 : 537.534.74

2703. The electric scattering of deuterons. U. E. KRUSE, N. F. RAMSEY AND B. J. MALENKA. Letter in *Phys. Rev.*, **89**, 655 (*Feb.* 1, 1953).

For $Ze^2/\hbar v \gg 1$, a departure from the Rutherford scattering formula is predicted for elastic Coulomb scattering of deuterons, owing to the polarizability of the deuteron, an effect neglected in the calculations of French and Goldberger [Abstr. 437 (1953)]. R. H. DALITZ

539.172.3

2704. Energy and angle distribution of the photoprotons from deuterium. M. WIENER. *Circ. Nat. Bur. Stand., No.* 515, 13 *pp.* (1951).

Formulae and graphs are given that describe the relationships between the energy of the photon which disintegrates a deuteron and the energy and direction of the resulting photoprotons. Data are also given for the conversion of angles from the laboratory to the centre-of-mass system of reference. The formulae are valid for all photon energies, whereas the graphs extend to 200 MeV. A.

539.172.3

2705. High energy photoproton production by 322-MeV bremsstrahlung. J. W. ROSENGREN AND J. M. DUDLEY. *Phys. Rev.*, **89**, 603–5 (*Feb.* 1, 1953).

The ejection of high-energy protons from various materials by 322 MeV bremsstrahlung has been investigated using a detector telescope consisting of three liquid scintillators. Protons, above a minimum energy of 65 MeV, were distinguished from other particles by their dE/dx at a fixed range. At 70 MeV the angular distribution appears to be independent of nuclear complexity; the relative distributions from Li, C and Ta have about the same shape. Distributions from C at 77, 127 and 174 MeV were measured between 11° and 45°. The data do not fit the predictions of a quasi-deuteron model, but adequate calculations require more knowledge of the deuteron photodissociation process. The yield at 45° for 72 and 142 MeV protons from various materials was found to be directly proportional to Z. The energy spectra of photoprotons from C have been measured at 45° and 90°. The absolute differential cross-section for production of 72 MeV protons from C at 90° has been measured. A.

539.172.3

2706. Cross section for the reaction $Be^9(\gamma,p)Li^8$. R. N. H. HASLAM, L. KATZ, E. H. CROSBY, R. G. SUMMERS-GILL AND A. G. W. CAMERON. *Canad. J. Phys.*, **31**, 210–17 (*Feb.*, 1953).

The reaction $Be^9(\gamma,p)Li^8$ has been investigated by detecting the 0·88 sec Li^8 β^- activity by the use of a cycling apparatus which allows intermittent operation of the betatron, counting taking place during the periods of no X-ray yield. The cross-section for the reaction has a peak value of 2·72 mbarns at 22·2 MeV, a half-width of 4·7 MeV and the integrated cross-section to 26 MeV is 0·013 MeV-barns. A.

539.172.3

2707. Observation of the $(\gamma, 2n)$ reaction in Ta. E. A. WHALIN AND A. O. HANSON. Letter in *Phys. Rev.*, **89**, 324 (*Jan.* 1, 1953).

The $(\gamma,2n)$ cross-section up to 22 MeV is deduced from the difference between the measured total neutron and radioactivity yields. The result agrees with predictions based on the statistical model. J. J. WILKINS

539.172.3

2708. Photoneutron cross sections in silicon and calcium. R. G. SUMMERS-GILL, R. N. H. HASLAM AND L. KATZ. *Canad. J. Phys.*, **31**, 70–7 (*Jan.*, 1953).

Using the dropping apparatus and dose monitoring method previously reported [Abstr. 9050 (1952)], the cross-sections for the reactions $Si^{28}(\gamma, n)Si^{27}$ and $Ca^{42}(\gamma, n)Ca^{39}$ have been measured by detecting positron activities in the residual nuclei. The $Si^{28}(\gamma, n)Si^{27}$ cross-section has a peak value of 21 mbarns at 20·9 MeV and an integrated cross-section to 24 MeV of 0·070 MeV-barns. The threshold energy is $16·9 \pm 0·1$ MeV. The $Ca^{40}(\gamma, n)Ca^{39}$ cross-section has a peak value of 15 mbarns at 19·3 MeV and an integrated cross-section to 24 MeV of 0·065 MeV-barns. The threshold is $15·8 \pm 0·1$ MeV. A comparison of the results with the neutron yield measurement of Price and Kerst at 18 and 22 MeV [Abstr. 5277 (1950)] gives good agreement. A further comparison with the neutron yield work of Baldwin and Elder [Abstr. 6060 (1950)] is made. The sharp discontinuity in (γ, n) yields using Li γ-rays observed by Wäffler and Hirzel [Abstr. 4150 (1949)] is explained as a threshold effect. Integrated cross-sections increase more or less smoothly with Z.

In addition, improved values for the half-lives of the residual nuclei Si^{27} and Ca^{39} have been measured. These are $4{\cdot}45 \pm 0{\cdot}05$ and $1{\cdot}00 \pm 0{\cdot}03$ sec respectively. A.

539.172.3

2709. The cross section for $Ta^{181}(\gamma, 2n)Ta^{179}$ at 17·6 MeV. J. H. CARVER, R. D. EDGE AND D. H. WILKINSON. Letter in *Phys. Rev.*, **89**, 658 (*Feb.* 1, 1953).

The ratio of this cross-section to the $Ta^{181}(\gamma, n)$ cross-section at 14·8 MeV is reported to be $0{\cdot}29 \pm 0{\cdot}11$ (experimental method not described). Calculations, based on this and other available data, predict that the total $(\gamma, n) + (\gamma, 2n)$ cross-section exhibits a single resonance peak at about 14 MeV. J. J. WILKINS

539.172.3

2710. Excitation function for meson production by γ-ray. S. MINAMI. *Progr. theor. Phys.*, **7**, 535–8 (*May–June*, 1952).

The excitation function for the production of π-mesons by γ-rays is calculated by the Lorentz-covariant perturbation method, taking into account the effect of higher orders. For π^0-meson production, various features have been obtained according to the theories adopted, while for charged π-meson production nearly similar dependence of cross-section upon the incident photon energy has unanimously been obtained. See also Abstr. 9053 (1952). A.

539.172.3

2711. Relation between the photoproduction and scattering cross sections for π-mesons in complex nuclei. N. C. FRANCIS AND K. M. WATSON. Letter in *Phys. Rev.*, **89**, 328–9 (*Jan.* 1, 1953).

Assuming the modification of the free nucleon cross-sections due to nuclear binding to be independent of A the proportionality of the 2 cross-sections is deduced from the optical model with a complex potential. W. J. SWIATECKI

539.172.3

2712. Photoproduction of neutral mesons in hydrogen. Y. GOLDSCHMIDT-CLERMONT, L. S. OSBORNE AND M. B. SCOTT. Letter in *Phys. Rev.*, **89**, 329 (*Jan.* 1, 1953).

Using a 320 MeV synchrotron beam and a hydrogen gas target, the recoil protons were detected by nuclear emulsions. The results are consistent with a cross-section proportional to $\rho^3 k$ (where ρ = meson momentum, $k = \gamma$-ray momentum in c.o.m. frame) and an angular distribution $a + b \sin^2\theta$, with $b/a = 5 \pm 3$. The theoretical implications are discussed. J. J. WILKINS

539.172.3

2713. The angular and energy distributions in photomeson production. B. T. FELD. Letter in *Phys. Rev.*, **89**, 330–1 (*Jan.* 1, 1953).

These are deduced by general methods for the process $\gamma + p \rightarrow p + \pi^{0+}$ for various angular momenta and parities of the intermediate state (proton isobar). Interference effects are discussed. Present experiments are consistent with an isobar of angular momentum $\frac{3}{2}$ in both ordinary and isotopic spin space. W. J. SWIATECKI

539.172.3

2714. Multiple scattering and the many-body problem—applications to photomeson production in complex nuclei. K. M. WATSON. *Phys. Rev.*, **89**, 575–87 (*Feb.* 1, 1953).

A study is made of the scattering of fast particles by atomic nuclei. A rigorous (formal) solution to the many-body Schrödinger equation is given which has the structure of a multiply scattered wave. The relation of this solution to the "impulse approximation" is discussed. A decomposition of the wave function into "coherent" and "incoherent" parts is effected. This makes it possible to derive the familiar "optical models" directly, as well as to find systematic corrections to these models. The theory is applied to a discussion of photomeson production in complex nuclei. A.

539.172.3

2715. Photoproduction of π^0 mesons in hydrogen and deuterium. N. C. FRANCIS. *Phys. Rev.*, **89**, 766–74 (*Feb.* 15, 1953).

Photoproduction of π^0 mesons in H and D is calculated in the weak coupling theory under several different assumptions regarding the interaction Hamiltonian. All calculations are performed non-relativistically taking into account the anomalous magnetic moments of the nucleons. The contribution of the negative energy states for the nucleons and of the nucleon current are isolated. Calculations are also performed with a phenomenological Hamiltonian which yields a $(2 + 3 \sin\theta')$ angular distribution in the centre-of-mass system for the photoproduction of π^0 mesons in H. In the case of D, the relative importance of elastic and inelastic photoproduction is examined as a function of photon energy, meson angle and the theoretical results are compared with recent experimental data. Best agreement with experiment is obtained if nucleon current effects are neglected. A.

539.172.3

2716. Some reactions produced in Ilford emulsions. W. K. DAWSON AND C. B. BIGHAM. Letter in *Canad. J. Phys.*, **31**, 167–8 (*Jan.*, 1953).

C_2 and E_1 emulsions were irradiated in a 70 MeV synchrotron beam. The cross-section curve for the $C^{12}(\gamma, 3He^4)$ reaction is given as a graph between 10 and 45 MeV X-ray energy. There are at least two narrow resonances. The $O^{16}(\gamma, 4He^4)$ curve is similar. Over half the stars observed had photons. Various reactions with C^{12}, N^{14} and O^{16} are given. F. R. HOLT

539.172.4

2717. Studies of the resonance absorption of neutrons in uranium with the time-of-flight method. E. HELLSTRAND AND R. PERSSON. *Ark. Fys.*, **6**, *Paper* 6, 57–68 (1952).

A 20-channel slow neutron time-of-flight spectrometer is described. The neutrons were produced by 7 MeV deuterons accelerated to a beryllium target, in a cyclotron with a modulated arc source. A study of the total cross-section of uranium showed three definite resonances with the constants (b = barn):

$E_0 = 6{\cdot}6 \pm 0{\cdot}2$ eV, $\sigma_0\Gamma^2 = 12{\cdot}4 \pm 1{\cdot}3$ b(eV)²,

$\sigma_0 = 5000 \pm \frac{2000}{1500}$ b, $\Gamma = 0{\cdot}050 \pm 0{\cdot}010$ eV

$E_0 = 20 \pm 2$ eV, $\sigma_0\Gamma^2 = 4{\cdot}5 \pm 2$ b(eV)².

$E_0 = 38 \pm 4$ eV, $\sigma_0\Gamma^2 = 6{\cdot}5 \pm 4$ b(eV)².

The constants given for the first resonance differ considerably from other results obtained by cruder methods (accurate measurements elsewhere by the time-of-flight technique are only now being declassified). A check run on the 5 eV resonance in silver showed satisfactory agreement with accepted results. J. M. CASSELS

539.172.4

2718. The thermal neutron capture cross section of ^{84}Sr. G. E. HARRISON AND F. D. SEYMOUR. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 958–9 (*Nov.*, 1952).

The isotopic capture cross-section of Sr^{84} was found to be $0{\cdot}32 \pm 0{\cdot}06$ barns, which is much smaller than the previously accepted value. J. M. CASSELS

539.172.4

2719. Measurement of total collision cross-sections for 14 MeV neutrons. M. AGENO, G. CORTELLESSA AND R. QUERZOLI. *R.C. Accad. Naz. Lincei*, **13**, 253–7 (*Nov.*, 1952) *In Italian.*

Results, for Cu, S, Al, O, P and Bi agree well with published results and theory. F. R. HOLT

539.172.4

2720. Neutron total cross sections. E. R. HODGSON, J. F. GALLAGHER AND E. M. BOWEY. *Proc. Phys. Soc.* [*London*] *A*, **65**, 992–4 (*Dec.*, 1952).

The neutron total cross-sections of Be, Na, Mo and Hg have been measured in the energy region 1 eV to 10 keV, and of Th between 1 eV and 1 keV, using the Harwell linear accelerator time-of-flight spectrometer. The energy resolution is better than in previously reported work on these elements, and several resonances have been more clearly resolved. A.

539.172.4

2721. Distribution in energy of the neutrons from the interaction of 14-MeV neutrons with some elements. E. R. GRAVES AND L. ROSEN. *Phys. Rev.*, **89**, 343–8 (*Jan.* 15, 1953).

The neutron spectra from the interaction of 14 MeV neutrons with a number of elements have been determined by nuclear plate techniques. The plates were exposed to neutrons from the bombardment of a Zr–T target by 200 keV deuterons when the target was as nearly as possible isolated from all scattering material and when the target was surrounded by a spherical shell of the element to be investigated. The variation of $F(E_n)$, the number of emitted neutrons per unit energy interval with energy (E_n), appears to be Maxwellian in the region $0{\cdot}5$ to $4{\cdot}0$ MeV and may be represented by $F(E_n)dE_n = CE_n e^{-E_n/T}dE_n$. A.

539.172.4

2722. Disintegration of helium by 90-MeV neutrons. P. E. TANNENWALD. *Phys. Rev.*, **89**, 508–17 (*Jan.* 15, 1953).

A detailed study of the fragments produced from He when bombarded by 90-MeV neutrons was made in a 22 in. cloud chamber filled with He gas and operated in a pulsed magnetic field of 22 000 gauss. The particles were identified by curvature and relative ionization, or by change of curvature with range when they stopped in the chamber. The energy of the incident neutron could be calculated from measured quantities for most modes of disintegration. The total number of events, for incident neutrons above 40 MeV, was normalized to the interpolated n-He^4 total cross-section of $1{\cdot}9 \times 10^{-25}$ cm^2; thus absolute cross-sections were established for the various disintegration processes. Energy dependences were compared and energy and angular distributions have been determined. A.

539.172.4

2723. Cross-section measurements of reactions induced by neutrons of 14·5 MeV energy. E. B. PAUL AND R. L. CLARKE. *Canad. J. Phys.*, **31**, 267–77 (*Feb.*, 1953).

The activation cross-sections were measured for 57 elements bombarded with 14·5 MeV neutrons from the $T^3(d, n)He^4$ reaction. Thirty-eight (n, p), twenty-five (n, α) and thirty-four $(n, 2n)$ reactions resulting in known radioactive products with half-lives between a few seconds and a few days were observed. The counting arrangement was calibrated using samples containing standardized quantities of radioactive materials. The neutron monitor was calibrated by counting the α-particles from the $T^3(d, n)He^4$ reaction. Calculations were made of the cross-sections predicted by evaporation theory and compared with the observed values. For the charged particle reactions with mass number greater than 100 the theoretical cross-sections were too small. Values of $\sigma_{obs}/\sigma_{cal}$ as high as 10 000 were obtained. However, the predicted cross-sections for the $(n, 2n)$ reactions were in general agreement with the observed values. A possible interpretation of these results is discussed. A.

539.172.4

2724. Average neutron total cross sections in the 3- to 12-MeV region. N. NERESON AND S. DARDEN. *Phys. Rev.*, **89**, 775–85 (*Feb.* 15, 1953).

An experiment is described for measuring average neutron total cross-sections over the 3 to 12 MeV energy region. The neutron source is a collimated beam of fast neutrons emerging from the Los Alamos Fast Reactor, and the detector is a proton recoil ionization chamber which serves as a neutron spectrometer. The average energy spread of the measurements is around 10%, and the over-all accuracy of the cross-section determinations is $\pm 10\%$ or better. Total cross-section results are presented for H, Be, C, O, Al, Si, S, Fe, Cu, Zr, Pb, Bi and U. Neighbouring elements above Fe are observed to exhibit regularities in their total cross-section patterns. A.

539.172.4

2725. On a simple picture of the phenomena of nuclear fission. D. CURIE. *C.R. Acad. Sci.* [*Paris*] **235**, 1286–8 (*Nov.* 24, 1952) *In French.*

Fission is pictured as the tearing away of an outer layer from a central core with $N \sim 82$, $Z \sim 50$. W. J. SWIATECKI

539.172.4

2726. The thermal neutron fission and capture cross section of U^{232}. R. ELSON, W. BENTLEY, A. GHIORSO AND Q. VAN WINKLE. Letter in *Phys. Rev.*, **89**, 320 (*Jan.* 1, 1953).

The fission cross-section is 83 ± 15 barns, and the capture cross-section is probably less than 500 barns. J. M. CASSELS

539.172.4

2727. Asymmetric fission. P. FONG. Letter in *Phys. Rev.*, **89**, 332–3 (*Jan.* 1, 1953).

The difference between the energy of the original nucleus and that of the two fragments in contact is greater for asymmetric division. If this difference is correlated with relative yields by a statistical level density formula the observed yield curve can be reproduced. W. J. SWIATECKI

539.172.4

2728. Radiochemical studies on the fission of Th^{232} with Li + D neutrons. A. TURKEVICH, J. B. NIDAY AND A. TOMPKINS. *Phys. Rev.*, **89**, 552–4 (*Feb.* 1, 1953).

The fission of Th^{232} with neutrons from Li bombarded with 7·6 MeV deuterons has been investigated radiochemically. The relative yields of fourteen mass chains, mostly in the light group, have been determined. The yields of symmetrical products are about tenfold higher than in the fission of Th^{232} with pile neutrons. Very light mass chains (very asymmetric fission) show a much smaller increase in yield. A.

539.172.4

2729. On the transient regime of nuclear reactors with reflectors. S. GALLONE AND L. ORSONI. *Nuovo Cimento*, **9**, 269–73 (*March*, 1952) *In Italian.*

The influence of the reflector on the transient behaviour of a nuclear reactor is considered, taking into account the prompt neutrons only. The critical size and the time constants are numerically evaluated for the case of a "flat" reactor. A.

539.172.4

2730. The "Swimming Pool"—a low cost research reactor. W. M. BREAZEALE. *Nucleonics*, **10**, 56–60 (*Nov.*, 1952).

The reactor is a thermal system in which fuel elements are submerged in a large pool of water. This acts both as a moderator, reflector and radiation shield. The fuel elements consist of Al-clad plates made from an alloy of Al and enriched U (more than 90% U^{235}). About 3 kg of U^{235} is used in a core of dimensions 12 in. × 12 in. × 24 in. high. The employment of a BeO reflector reduces the critical size by about 20%. Control is exercised by means of boron carbide absorbing rods. The maximum thermal and epithermal neutron fluxes are 10^{12} and 3×10^{12} n/cm²/sec respectively. The operating power is nominally 100 kW, the heat being removed by natural convection. This reactor has many advantages, including cheapness, safety and extreme versatility as a research tool. L. R. SHEPHERD

539.172.4

2731. Applications of pile-kinetic equations. H. S. ISBIN AND J. W. GORMAN. *Nucleonics*, **10**, 68–71 (*Nov.*, 1952).

The method of deriving the equations governing the time dependence of neutron flux in large graphite-uranium piles, following step changes in reactivity, is outlined. The time dependence is given by a series of seven exponential terms, one having a positive exponent and the others (corresponding to the six delayed neutron groups in U^{235} fission) having negative coefficients and exponents. Both coefficients and exponents are graphed as a function of reactivity for positive reactivity steps. The behaviour of a pile for a positive reactivity change of 0·003 is derived by way of illustration and it is shown, in this case, that the two-term solution, in which one term represents the effect of prompt neutrons, and the other a combined delayed neutron effect, gives very poor agreement with the rigorous solution. L. R. SHEPHERD

539.172.4

2732. Storage of radioactive gases from reactor operation. R. L. MURRAY. *Nucleonics*, **10**, 52–3 (*Dec.*, 1952).

The reduction in concentration of a gaseous fission product (in particular Xe^{133}) in continuous discharge from a reactor, through a series of holding tanks, is analysed. The analysis is extended to the case of intermittent reactor operation. L. R. SHEPHERD

539.172.4

2733. An experimental study of a divergent nuclear reactor. J. G. BAYLY. *Canad. J. Phys.*, **31**, 182–9 (*Feb.*, 1953).

Experimental measurements of the relaxation times of a nuclear reactor were compared with the theoretical relaxation times in the range 1·6 to 186 sec. The work was done with the Chalk River Zero Energy Experimental Pile, ZEEP, in 1947, and showed that agreement within the experimental error could be obtained if the theoretical model used to represent the reactor was of the age-velocity type with a correction for the effect of the reflector. A.

ATOM AND MOLECULE BEAMS . MESONS NEUTRONS 539.18

539.18

2734. A new example of τ meson. M. CECCARELLI, N. DALLAPORTA, M. MERLIN AND A. ROSTAGNI. *R.C. Accad. Naz. Lincei*, **13**, 9–14 (*July–Aug.*, 1952) *In Italian.*

An example of disintegration of a τ-meson into three co-planar particles was observed in a plate exposed on Mount Rosa. The angles between the traces, and the grain density could be measured fairly accurately. A discussion shows that practically the only tenable hypothesis is that all three decay products are π-mesons. The mass of the τ-meson then comes to $(991 \pm 15)m_e$. L. PINCHERLE

539.18

2735. Multiple meson production in nucleon-nucleon collisions. H. W. LEWIS. *Rev. mod. Phys.*, **24**, 241–8 (*Oct.*, 1952).

A critical review of the theories of Heisenberg (1949), Fermi (1951), Lewis, Oppenheimer and Wouthuysen (1948), Fukuda and Takeda (1950), Umezawa *et al.* (1952), Clementel and Dallaporta (1948), Glauber (1951). The influence of the nucleon isobar energies is discussed. The possibility of one of the nucleons declining to emit mesons as a consequence of the energy-momentum balance is considered in some detail and contrasted with the apparent absence in nature of nuclear stars with a highly asymmetric cone of mesons. W. J. SWIATECKI

539.18

2736. Multiple meson production by high energy nucleon-nucleon collisions. H. FUKUDA. *Phys. Rev.*, **89**, 842–7 (*Feb.* 15, 1953).

A comparison is made between Fermi's theory and Lewis, Oppenheimer and Wouthuysen's theory of multiple meson production in high-energy nucleon-nucleon collisions, and an analysis is made of some typical examples. The main difference between the two theories concerns the Lorentz covariance of the matrix element which is related, in Fermi's theory, to the Lorentz contraction of the volume in which the thermal equilibrium of virtual mesons is supposed to be established, and to the Lorentz invariant phase volume in L.O.W.'s theory. It is reasonable to take the contracted diameter of the volume in Fermi's theory to be of the order of the wavelength of the emitted meson (not that of the incident nucleon), and as a result both theories can explain to some extent the multiplicity and angular distribution. The main difference lies in the average energy of the emitted mesons in the centre-of-mass system as a function of multiplicity. A.

539.18

2737. Gamma radiation emitted in the pi-mu decay. G. E. A. FIALHO AND J. TIOMNO. *Notas de Fisica, No.* 1, 4 *pp.* (1952). Also in *An. Acad. Brazil Cienc.*, **24**, *No.* 3, 245–8 (1952).

The probability for $\pi \rightarrow \mu + \nu + h\nu$ is computed for a μ with spin $\frac{1}{2}$ and a pseudoscalar π. The results are compatible with the observed number of short range μ's (0·03% of total). A knowledge of the experimental energy spectrum of the μ may serve to determine its spin. W. J. SWIATECKI

539.18

2738. On the low energy mu-meson from pi-meson decay. G. E. A. FIALHO. *Notas de Fisica, No.* 3, 4 *pp.* (1952).

The calculation of the preceding abstract is repeated, assuming in addition an anomalous magnetic moment for the μ. More precise experimental data on the frequency of short μ tracks would serve to determine this quantity. W. J. SWIATECKI

539.18

2739. A suggested scheme for meson production. H. MESSEL AND H. S. GREEN. Letter in *Phys. Rev.*, **89**, 315–16 (*Jan.* 1, 1953).

A classification of observed particles based on the properties of 1st order wave equations and the existence of "isobars." Masses of the heavy mesons would be multiples of the π mass. The nucleon would be analogous to an H atom with a charged or neutral massive core and an electron or neutrino bound to it by meson forces and capable of absorbing or emitting meson "quanta" giving rise to isobars [see G. Wentzel, *Z. Phys.*, **104**, 34 (1936); **105**, 738 (1937)]. W. J. SWIATECKI

539.18

2740. The internal pair production of γ-rays of mesonic origin; alternate modes of π^0 decay. P. LINDENFELD, A. SACHS AND J. STEINBERGER. *Phys. Rev.*, **89**, 531–7 (*Feb.* 1, 1953).

The internal pair creation of the γ-rays in the processes (1) $\pi^0 \rightarrow \gamma + \gamma$, (2) $\pi^- + P \rightarrow \gamma + N$, has been observed. The experimental conversion coefficient $\beta = 0{\cdot}0080 \pm 0{\cdot}0016$ is to be compared to the theoretical prediction, 0·0063. In addition, an upper limit has been obtained on the fraction of neutral pions which decay directly into a pair: $\pi^0 \rightarrow e^+ + e^-$. The limit is one in 2000. A.

539.185

2741. Notes on the decay of the neutron. I–II. T. KOTANI, H. TAKEBE, M. UMEZAWA AND Y. YAMAGUCHI. *Progr. theor. Phys.*, **7**, 469–80 (*May–June*); **8**, 120–32 (*July*, 1952).

The β-decay of the neutron is theoretically discussed and compared with the experimental results of Robson. As was first pointed out by Berestetsky and Pomeranchuk (1949), the form of the β-spectrum derived on the pseudoscalar interaction is different from the so-called allowed spectrum. The final decision about the type of interaction is not, however, offered from the β-spectrum alone. Attempts are therefore made to obtain some theoretical predictions which might be useful for the decision of the interaction type when compared with some future experiments. They are the angular correlation of electrons and protons and the momentum spectrum of protons. The calculation shows that in principle it is possible, though not easy, to carry through such experiments. The β-spectrum obtained by Robson is not reliable in the low-energy region, but an explanation is given how to account for the shape of the spectrum in this region, if the observed spectrum is correct there. A.

539.185

2742. A method for the computation of plural and multiple scattering corrections. J. BLOK AND C. C. JONKER. *Physica*, **18**, 809–22 (*Nov.*, 1952).

A method is given for computing the angular distribution of scattered particles starting from a function for the differential cross-section; this angular distribution depends on single, plural and multiple scattering. The thickness of the scatterer has been taken about equal to the mean free path of the particles inside the scatterer. An application is given for the case of scattering of thermal neutrons by a thin sheet of paraffin. In the appendix is discussed the differential cross-section in the laboratory system for the scattering of thermal neutrons by paraffin. A.

539.185

2743. Scattering of thermal neutrons by bound protons and deuterons, J. BLOK AND C. C. JONKER. *Physica*, **18**, 823–35 (*Nov.*, 1952).

With a neutron howitzer and a Ra–Be source (400 mg Ra) some experiments were performed on the angular distribution of thermal neutrons scattered in paraffin, water, heavy water, ice and heavy ice. By using a method previously described (preceding abstract), some data about the differential cross-section for the scattering processes have been found. The differential cross-section of paraffin, water and ice differ much from spherical symmetrical functions; for heavy water and heavy ice the differences are much smaller. For paraffin the distribution computed after the model of Arley deviates from the experimental values; the experimental data suggest a more forward directed scattering. From the data for water and ice it may be concluded that the binding of the proton in

ice is stronger than in water. Interference effects were observed; especially in the curves for heavy water and heavy ice. A.

539.185

2744. Determining neutron fluxes from a pulsating radiator. A. BRODSKY. *Nucleonics*, **10**, 36–9 (*Dec.*, 1952).

An expression is derived, relating the average value of the neutron flux from a pulsating source to the counting rate in a fast neutron detector, the duration of the pulse being less than, and the interval between the pulses greater than the resolving time of the counter. The results have been applied in monitoring the fast neutron flux in the vicinity of a 23 MeV betatron, by means of a methane proportional counter. L. R. SHEPHERD

539.185

2745. Neutron scattering by coupled paramagnetic ions. P. J. BENDT. *Phys. Rev.*, **89**, 561–9 (*Feb.* 1, 1953).

The paramagnetic scattering of very low energy neutrons by MnF_2 and MnO was studied at various sample temperatures. The assumption of Van Vleck, that a Gaussian distribution can be used to represent the frequency of inelastic scattering events, *v.* energy transfer with the spin lattice, is used, and the root mean square half-width of the distribution of energy transfer for MnF_2 is found to be 0·0020, 0·0026 and 0·0034 eV at 610°, 300° and 126°K, respectively. Short-range order scattering modifies the scattering cross-section for MnF_2 to the extent of $1 \cdot 5/4\pi$ barns/steradian at 126°K, but is not observed at higher temperatures. Measurements at 300°K indicate the magnetic scattering cross-section for MnO, if it were not distorted by short-range order scattering, would be about $2 \cdot 5/4\pi$ barns/steradian lower than for MnF_2. It is suggested that this may be accounted for by the mechanism of super-exchange between crystal ions. Rough values of a parameter indicating the range of spin order in MnO were determined at 300° and 133°K. The amount of spin order increases with decrease in sample temperature. Above the Néel temperature, it is found that most of the correlation of spin direction exists only between adjacent ions on the same sublattice. A.

539.185

2746. A cloud-chamber study of the scattering of fast neutrons in oxygen. J. P. CONNER. *Phys. Rev.*, **89**, 712–14 (*Feb.* 15, 1953).

Neutrons with an energy of 14·1 MeV have been scattered in O gas, and the recoil O nuclei observed in a cloud chamber operated at a pressure of $\frac{1}{3}$ atmosphere. Recoils from elastically scattered neutrons were resolved from recoils due to inelastic scattering. The results indicate a strong asymmetry in the angular distribution of elastically scattered neutrons; the angular distribution has maxima at 0°, 80° and 180° and minima at 60° and 130°. Within a factor of 2, the angular distribution for the inelastically scattered neutrons is symmetrical. The probability per unit energy interval that the O nucleus will be left excited is about 5 times as large at 6 MeV excitation as at 12 MeV. The cross-section of O for 14·1 MeV neutrons is $0 \cdot 7 \times 10^{-24}$ cm² for elastic scattering, $0 \cdot 5 \times 10^{-24}$ cm² for inelastic scattering and $0 \cdot 4 \times 10^{-24}$ cm² for disintegration. A.

539.185 : 532.74

2747. Neutron diffraction and atomic distribution in liquid lead and liquid bismuth at two temperatures. P. C. SHARRAH AND G. P. SMITH. *J. chem. Phys.*, **21**, 228–32 (*Feb.*, 1953).

Neutron diffraction patterns have been obtained on liquid lead and liquid bismuth at two temperatures. The patterns differ only slightly at the different temperatures, the main peak being slightly shorter and broader and shifted slightly to smaller angles at the higher temperatures. The diffraction patterns have been analysed to obtain information on the atomic distribution. The first main peak in the distribution curve for liquid lead is at 3·40Å and represents about 9·4 atoms. The first main peak in the curve for liquid bismuth is at 3·35Å and represents about 7·7 atoms. The second most prominent concentration of atoms occurs at 6·6Å for both lead and bismuth. A.

539.185 : 548.7

2748. On the influence of spin and isotopes in the kinematical theory of neutron diffraction. P. O. FRÖMAN. *Ark. Fys.*, **6**, *Paper* 11, 113–17 (1952).

The Born approximation and the Fermi pseudo-potential are used to formulate the problem in the usual way [for references see Squires, Abstr. 4634 (1952)]. Two limiting cases are briefly discussed. J. M. CASSELS

539.185 : 548.736.3

The lattice expansion of quartz due to fast neutron bombardment. *See Abstr.* 2826

STRUCTURE OF SOLIDS 539.2

539.211 : 535.417

An interferometric examination of polished diamond surfaces. *See Abstr.* 2384

539.211 : 539.89 : 541.126

2749. Free surface properties of explosive-driven metal plates. R. G. SHREFFLER AND W. E. DEAL. *J. appl. Phys.*, **24**, 44–8 (*Jan.*, 1953).

A photographic technique for study of metal free surfaces under acceleration by high explosives is presented. Methods for reducing the data from the photographic record are described. Specific results using brass plates driven by Composition B explosive are cited. A.

539.215.7 533.27 532.73

The definition and measurement of some characteristics of mixtures. *See Abstr.* 2249

539.217

2750. The measurement of the hydraulic permeability of saturated soil *in situ*. I. Principles of a proposed method. E. C. CHILDS. *Proc. Roy. Soc. A*, **215**, 525–35 (*Dec.* 22, 1952).

A steady-state method is described for measuring the permeability of soil *in situ*; it is applicable only to saturated soil below the water table. A pair of small

wells, in one of which is placed a pump, forms a water circulating system. The pump depresses the level in one well and the pumped water, being passed through a flowmeter and emptied back into the second well, maintains a level in the latter higher than the static equilibrium level. The difference of levels in the wells is related to the rate of flow of water and to the soil permeability. In anisotropic media the method gives apparent horizontal permeability. The use of two pairs of wells, the planes containing the axes of each pair being suitably oriented, enables us to determine the permeabilities in the directions of the horizontal axes of anisotropy. Combination of this method with Kirkham's, which provides an estimate of apparent permeability which is dependent upon both horizontal and vertical permeabilities, enables the axial permeabilities of triaxially anisotropic material to be calculated. A.

539.217

2751. An analytical method of calculating variable diffusion coefficients. L. D. HALL. *J. chem. Phys.*, **21**, 87–9 (*Jan.*, 1953).

The Matano–Boltzmann method of graphical calculation of diffusion coefficients in solutions is replaced by an analytical method in certain systems. This procedure enables accurate calculation of diffusion coefficients near the concentration extremes. An equation is derived for the diffusion coefficient D as a function of concentration c. The equation predicts a variation of D with c which is not exponential in metallic systems, contrary to the proposal of Wagner. Comparison of D values with those obtained graphically, for the system copper-nickel, indicates that the graphical values may be appreciably in error at that extreme where the diffusion coefficient is greatest. A.

539.217 : 541.135

2752. The transmission of hydrogen through palladium by electrolysis. H. B. WAHLIN AND V. O. NAUMANN. *J. appl. Phys.*, **24**, 42–4 (*Jan.*, 1953).

Whenever a metal is made the cathode in a dilute sulphuric acid bath, the transmission of hydrogen may be observed by means of its reaction with oxygen of the air. A more detailed study of the transmission through palladium shows that the area of the surface at which the hydrogen leaves is the principal controlling factor. Possible applications to hydrogenation studies are discussed. A.

539.217 : 548.736.3

2753. Isothermal ordering of Cu_3Au at 200°C. E. K. HALTEMAN, G. F. MECHLIN AND H. L. GLICK. Letter in *Phys. Rev.*, **88**, 1205 (*Dec.* 1, 1952).

The manner in which the resistance changes with time during the annealing at 200°C of initially disordered samples, follows closely that observed by Blewitt and Coltman [Abstr. 3907 (1952)] during the neutron irradiation at the same temperature of similar samples. A. D. LE CLAIRE

539.219.1

2754. The equilibrium diagram of the system In–Pb. V. S. KOGAN AND B. YA. PINES. *Dokl. Akad. Nauk SSSR*, **87**, *No.* 5, 771–3 (1952) *In Russian.*

Alloys of In–Pb (up to 40 at. % Pb) were examined by X-ray and electrical conductivity methods at temperatures up to their melting points. Hitherto doubtful features of the equilibrium diagram were filled in. At room temperature the α-phase is stable from 0–13 at. % Pb, the γ-phase from 14–30% and the β-phase from 32–100%. The γ-phase appears to be tetragonal with $c/a \simeq 0{\cdot}95$, $a \simeq 4{\cdot}7$Å and gives to a first approximation a powder pattern like that of Pb.

A. L. MACKAY

539.219.1

2755. The existence of a macroscopic shear in the transformation in cobalt. T. R. ANANTHARAMAN AND J. W. CHRISTIAN. Letter in *Phil. Mag.*, **43**, 1338–42 (*Dec.*, 1952).

Thin plates of hexagonal Co, produced by heating polycrystalline samples in H_2 to about 415°C, intersect the surface of the specimen to give the appearance of Neumann bands. The habit plane was identified as ⟨111⟩, consistent with there never being in any one grain more than 4 directions of the lines of intersections. The mechanism of transformation is discussed but not settled, although the present observations suggest that an independent spreading of stacking fault nuclei cannot be responsible.

A. D. LE CLAIRE

539.232 : 539.27

2756. The thermal oxidation of tin. R. K. HART. *Proc. Phys. Soc.* [*London*] *B*, **65**, 955 (*Dec.*, 1952).

Electron diffraction experiments show that when tin foil is thermally oxidized in air an amorphous oxide layer is formed at temperatures up to 130°C. Above 130°C only crystalline SnO and SnO_2 are formed. A.

539.26 : 532.74

2757. The structures of liquid tin, bismuth and lead. A. I. DANILOVA, V. I. DANILOV AND E. Z. SPEKTOR. *Dokl. Akad. Nauk SSSR*, **82**, *No.* 4, 561–4 (1952) *In Russian.*

X-ray scattering curves were obtained in a vacuum camera from liquid metals, monochromatization being achieved by the use of differential filters with Cu and Ag radiations. By transforming the scattering curves to radial density curves and summing the areas under peaks in the latter, estimates were obtained of the coordination of atoms in the liquid state. These were found to be 10 for Sn, 7–7·5 for Bi and 11 for Pb. Smaller peaks were found for second and third nearest neighbours. A. L. MACKAY

539.26 : 539.4.016.2

2758. X-ray studies of polycrystalline metals deformed by rolling. I. The examination of the harder metals, copper, nickel and iron. P. GAY AND A. KELLY. *Acta Cryst.*, **6**, 165–72 (*Feb.*, 1953).

The recently developed X-ray microbeam technique has been applied to the study of polycrystalline metals deformed by rolling. In this way it is possible to obtain information both about the mode of deformation of the material and about the nature of the cold worked state. Similarities in the behaviour of soft and hard metals are found and the results are discussed in terms of current theories of metallic strength. This paper contains only the results of the investigations of typical hard metals, Cu, Ni and Fe. It is found that a limiting particle size is reached when these metals are heavily rolled, and that the particles are distorted. A.

539.26 : 539.4.016.2

2759. X-ray studies of polycrystalline metals deformed by rolling. II. Examination of the softer metals, tin, zinc, lead and cadmium. P. GAY AND A. KELLY. *Acta cryst.*, **6**, 172–7 (*Feb.*, 1953).

X-ray back-reflection methods, employing both beams of normal diameter and microbeams, were used. In the initial stages of deformation a mosaic structure is found within the deformed grains of the metal and the size of the mosaics reaches a lower limiting value, dependent on the particular metal. At heavy deformations these metals spontaneously recrystallize. The effects upon the mosaic structure of annealing at low temperatures and of recovery at room temperature have been studied. Some evidence is presented concerning the nature of recrystallization nuclei. A.

539.27

2760. A new method of making preparations for electron microscopic examination of the surface structure of metals. I. SHUGAR [SUGÁR]. *Acta tech. Hungar.*, **5**, *No.* 1, 57–69 (1952) *In Russian.*

Graphitic formations in iron specimens were examined with the electron microscope. When polystyrene-silica replicas, prepared in the usual way, were used, it was found that structural features, having lower relief than the graphite particles themselves, could not be seen in adequate detail. It was concluded that positive replicas less than 100Å thick were necessary. It was found that metallic films, prepared by evaporating two different metals simultaneously or consecutively, could retain sufficient mechanical strength even when only 40Å thick. Au and Al appeared to be the best combination giving very satisfactory image contrast and better resolution while not recrystallizing under the electron bombardment as did pairs of metals such as Cr and Cd.

A. L. MACKAY

539.27

2761. A combination of electron microscopy and optical phase-contrast microscopy. S. YAMAGUCHI. *J. appl. Phys.*, **23**, 1404 (*Dec.*, 1952).

An electron micrograph of an oxide replica was magnified optically in a form of phase contrast microscope. The resulting picture showed none of the replica granularity seen with the normal form of optical magnification. R. S. PEASE

539.27

2762. Preparation of uniformly dispersed specimens of particulate matter for electron microscopy. R. E. HARTMAN, T. D. GREEN, J. B. BATEMAN, C. A. SENSENEY AND G. E. HESS. *J. appl. Phys.*, **24**, 90–2 (*Jan.*, 1953).

The transfer of monolayers of proteins to solid surfaces from a liquid substrate is now a well-established procedure. It has been found that if particulate matter is present in the protein solution from which the monolayer is to be formed, the surface streaming set up by the spreading of the protein over the surface of a liquid substrate causes the particles to be distributed uniformly throughout the available surface. They can then be transferred to a solid surface along with the protein monolayer. This procedure has been used in the preparation of specimens for electron microscopy by raising previously immersed collodion-coated wire mesh screens, attached to glass microscope slides, through the interface occupied by the monolayer. Micrographs of viruses, bacteria and other bodies mounted in this manner have been obtained. The method commends itself by virtue of the simplicity of the procedure, the uniform dispersion of the particles, the elimination of interference from extraneous dissolved substances and the high quality of the micrographs obtained. A.

539.27 : 537.533.72

Practical electron microscopy. *See Abstr.* 2489

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.32

2763. The determination of relaxation times from the elasticity of rebound. E. JENCKEL AND E. KLEIN. *Z. Naturforsch.*, 7a, 619–30 (*Sept.*, 1952) *In German.*

A steel ball is dropped on to the horizontal plane surface of a test-piece of solid high polymer and the height of rebound is measured at temperatures between 20°C and 250°C: experiments with polystyrene and polymethyl methacrylate (cross-linked or not), polyvinyl chloride and polyurethane are described. As the temperature increases the rebound drops to a minimum, usually zero, and later increases to a high constant value (for cross-linked polymers) or to a maximum followed by a fall to zero. The phenomena are explained in terms of the authors' theory of the mechanical behaviour of a material with a single relaxation time and two elastic moduli [see Abstr. 8014 (1952)]. The manner in which the relaxation time decreases with increasing temperature is deduced. A discussion of the case of a continuous spectrum of relaxation times is included. J. G. OLDROYD

539.32

2764. The elastic constants of Cu — 4 percent Si. C. S. SMITH AND J. W. BURNS. *J. appl. Phys.*, **24**, 15–18 (*Jan.*, 1953).

The elastic constants of a Cu — 4 atom % Si crystal have been determined by the pulsed ultrasonic method to be $C_{11} = 1{\cdot}62$, $C_{12} = 1{\cdot}20$ and $C_{44} = 0{\cdot}755$, all in units of 10^{12} dyne cm^{-2}. The changes in the fundamental shear constants C_{44} and $\frac{1}{2}(C_{11} - C_{12})$ owing to alloying have been expressed in terms of a change in electrostatic stiffness and a change in ionic stiffness, both of which are shown to be reasonable. The experimental ionic effect is interpretable in terms of the solute-solvent ion core interaction and the local distortions around a solute atom. The previously known results for Cu — 28% Zn also conform to this picture. A.

539.32 : 539.67

2765. Temperature dependence of the elastic moduli and internal friction of silica and glass. J. W. MARX AND J. M. SIVERTSEN. *J. appl. Phys.*, **24**, 81–7 (*Jan.*, 1953).

The dynamic Young's moduli and the internal friction of fused quartz, Pyrex glass and soft glass rods were measured at a frequency of 37 kc/s, in longitudinal vibration, within the temperature range —170°

to 1000°C. The moduli of Pyrex and quartz increased with rising temperature, up to the softening point of the glass, while that of soft glass decreased. All three moduli were approximately linear with respect to the temperature over most of the measurement interval. Internal friction maxima were noted at high temperatures, while at the lowest measurement temperatures a significant increase in background damping occurred. A brief recapitulation of existing theory is given and employed to interpret the internal friction data. It is suggested that, in microscopically inhomogeneous media, the diffusion measurement by internal friction methods is not equivalent to the determination by other techniques. A.

539.374

2766. On the value of Poisson's coefficient in elasto-plastic phenomena. G. COLONNETTI. *C.R. Acad. Sci. [Paris]* **235,** 1460–2 (*Dec.* 10, 1952) *In French.*

A reply to criticisms of the author's theorem [Abstr. 586–8 (1952)] concerning the conditions for no change in shape of a body under internal stresses. R. A. NEWING

539.374

2767. The determination of the energy stored in a metal during plastic deformation. L. M. CLAREBROUGH, M. E. HARGREAVES, D. MICHELL AND G. W. WEST. *Proc. Roy. Soc. A*, **215,** 507–24 (*Dec.* 22, 1952).

A new apparatus for measurement of the stored energy is described and the results obtained are presented. The method involves the heating, *in vacuo*, of an annealed and a deformed specimen, of equal weight, by small heating elements located inside each specimen. During heating the specimens are kept at the same temperature as each other, and they are surrounded by a metal shield continuously adjusted to this temperature. The stored energy is calculated from measurements of the difference in the powers supplied to the specimens made by means of a differential wattmeter constructed for this purpose. The apparatus has proved to be capable of measuring, with an accuracy of $\pm 5\%$, a difference of 0·1 cal/g in the energy supplied to the specimens in heating them through a temperature range of 240°C in a period of 40 min. Results are given for specimens of electrolytic Cu deformed in torsion, and they show that the stored energy increases with deformation in a similar way to the torque required to produce the deformation. Small amounts of some impurities appear to be responsible for large differences both in the recrystallization temperatures and in the shapes of the curves showing the release of the stored energy as a function of temperature, but the total stored energy is not changed markedly. However, in other cases impurities may produce a significant alteration in the stored energy. It is suggested that differences in composition are the cause of discrepancies between the present results and those of previous workers. A.

539.374

2768. Remarks concerning the paper "Conditions for the derivation of the stress deviator tensor." M. O. PEACH. Letter in *Amer. J. Phys.*, **21,** 64–5 (*Jan.*, 1953).

Extension of remarks on the derivation of the stress deviator tensor. O. L. ANDERSON. *Ibid.*, 65–7.

See Abstr. 4670 (1952). A discussion of the significance of the decomposition of the stress and strain tensors into independent constituents in plasticity theory. J. G. OLDROYD

539.4.014.1

2769. The initial yield in iron. H. W. PAXTON. Letter in *J. appl. Phys.*, **24,** 104–5 (*Jan.*, 1953).

Polycrystalline iron prestressed above the lower yield stress, unloaded to 10 kg/mm², and aged for 1 hour at 100°C, shows a marked increase in upper yield stress. The elimination of stress concentrations by the ageing treatment is indicated. Similar observations were made on single crystals. J. G. OLDROYD

539.4.016.2 : 539.26

2770. X-ray study of cold work in thoriated tungsten. M. MCKEEHAN AND B. E. WARREN. *J. appl. Phys.*, **24,** 52–6 (*Jan.*, 1953).

Spectrometer measurements were made of the X-ray diffraction peaks for cold-worked filings of thoriated tungsten: 99·25 tungsten, 0·75 thoria. A Fourier analysis was made of the peak shapes, and the instrumental broadening corrected by using the peaks of annealed material. When the particle size and the distortion effects were separated, it was found that the particle size broadening corresponded to a size $\bar{L} = 200$Å. This value is to be interpreted as the size of the coherently diffracting domains, and is a measure of the distance between layers of slip planes or layers of dislocations. The coherent distortion broadening indicated that strains in this material vary appreciably over distances of 25Å or less. Strain distribution curves were obtained from a Fourier transform of the experimental coefficients. There is an indication that strains are smaller in the larger coherent regions. The measured root mean square strain corresponds to an elastic energy of 0·18 cal/g. Within experimental accuracy the integrated intensities are the same for the cold-worked or the annealed samples. A.

539.501

2771. A generalized fluidity power law and laws of extrusion. M. MOONEY AND S. A. BLACK. *J. Colloid Sci.*, **7,** 204–17 (*June*, 1952).

Raw rubbers are assumed to obey the fluidity power law, $\phi = f\tau^{n-1}$, ϕ = fluidity, τ = shearing stress, $n > 1$. For three-dimensional flow the generalized law is assumed to be $\phi = gW^{(n-1)/(n+1)}$, where W = rate of energy dissipation. It is shown that this law is equivalent to Nadai's three-dimensional law of steady creep, expressed in terms of the octahedral shearing stress and octahedral rate of shear. On the basis of the fluidity power law, laws of extrusion are derived for circular and slit tubes and orifices, surface slip also being included in the analysis. By dimensional analysis a general theorem is established concerning the effects of stress (or pressure) and apparatus dimension on deformation and flow rates. Experimental data, obtained with circular tubes of various lengths and diameters and covering a 100-fold range in extrusion rates, agree roughly with the power form of the derived extrusion laws, but do not give the expected values of the exponent n in some cases. Surface slip was too small to measure in the present experiments. A.

539.61

2772. On the measuring of cohesional forces of solids, as influenced by liquids. C. BENEDICKS AND B. EKELUND-KAPPELER. *Ark. Fys.*, **6**, *Paper* 8, 73–9 (1952).

Experiments on the adhesion between two surfaces of polished brass are reported. R. F. BARROW

539.62

2773. Solid solubility effect of metallic surface friction. K. UMEDA AND Y. NAKANO. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 70–86 (*Feb.*, 1951).

The temperature dependence of the metallic surface friction was studied experimentally for a number of metal pairs by the improved Bowden method. In particular, for metal pairs of limited solubility type the "solid solubility effect" embodied by the formula: $\mu_\theta = (\alpha_{eutec} - \alpha_\theta)/k$ was found. Furthermore, similar phenomena are examined for metal pairs of simple eutectic, continuous solubility, intermetallic compounds, intermediate phase types and solidified mercury as a component. The results seem to favour the local melting theory of Bowden *et al.* A.

539.62

2774. On Bowden's stick-slip lengths of surface friction. Y. NAKANO. *J. Fac. Sci. Hokkaidô Univ. II*, **4**, 87–9 (*Feb.*, 1951).

The frequency distribution of the Bowden stick-slip lengths was investigated in its dependence on the melting point by means of chlorides and oxides, since the melting points of these are lower and higher than that of the pure metal respectively. A.

539.67 : 534.15

2775. Apparatus for measuring internal friction in transversely vibrating metal reeds. W. R. JEWELL. *Rev. sci. Instrum.*, **24**, 5–10 (*Jan.*, 1953).

Describes apparatus for nonferromagnetic reeds. It includes a description of a symmetrical transducer for inducing the vibrations and an optical method of observing the amplitude. Measurements can be made while the reed is temperature-controlled and vibrating in a vacuum. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.124

2776. Methods of investigating reactions between gases and solids. Application to the iron–carbon–hydrogen system. L. BEAUJARD, G. COLLETTE AND L. JACQUÉ. *C.R. Acad. Sci.* [*Paris*] **235**, 1388–90 (*Dec.* 1, 1952) *In French.*

The method is based on the continuous recording of the specimen weight by means of a magnetic junction between an internal balance beam to which the specimen is attached and an external beam belonging to the recording balance. When applied to the Fe–C–H_2 system, the method has given results differing by up to 16% from those of Austin and Day (*Controlled Atmosphere*, Cleveland (1942), pp. 20–56). F. LACHMAN

541.124

2777. Some thermal reactions of the higher iron carbides. E. M. COHN AND L. J. E. HOFER. *J. chem. Phys.*, **21**, 354–9 (*Feb.*, 1953).

One of the undesirable side reactions of the Fischer–Tropsch synthesis is deposition of carbon. To ascertain whether thermal reactions of iron carbides might cause this deposition and to learn more about the nature of iron carbides, the transition from hexagonal close-packed (h.c.p.) iron carbide to Hägg iron carbide and the reaction of higher iron carbide with metallic iron to form cementite have been studied in a copper- and alkali-promoted iron catalyst by means of a magnetic balance. The transition from h.c.p. to Hägg iron carbide is heterogeneous, with no apparent change of the compositions of both carbides, nor any detectable solubility of one carbide in the other. The data confirm the narrow range of composition of Hägg carbide and the fact that it contains somewhat more iron than corresponds to the formula Fe_2C. The synthesis of cementite from metallic iron and higher iron carbide proceeds via Hägg carbide and only above about 320°C. It does not go to completion up to 440°C; above that temperature, decomposition of Hägg carbide into cementite and free carbon is sufficiently rapid to prevent completion of the synthesis. The data show that deposition of carbon on iron catalysts during the Fischer–Tropsch synthesis is not caused by thermal reactions of iron carbides, unless h.c.p. iron carbide should contain more carbon than Hägg iron carbide. A possible explanation of the apparent stabilizing effect of copper on h.c.p. iron carbide is given. A.

541.124 : 536.75

2778. Entropy changes in free radical reactions. A. F. TROTMAN-DICKENSON. *J. chem. Phys.*, **21**, 211–14 (*Feb.*, 1953).

The entropies of alkyl and other simple free radicals may be estimated with sufficient accuracy to make informative calculations about the equilibria involved in the reactions of these radicals. Such calculations have been made for metathetical reactions, the decomposition of saturated molecules and the decomposition of free radicals. The method provides a means of obtaining knowledge about reactions which are not readily susceptible to direct experimental investigation. The deviations of the frequency factors of some unimolecular decompositions from a value of $10^{13\pm1}$ are discussed. A.

541.124.7

2779. The dissociation of H_2 and N_2 on tungsten filaments. M. FARBER AND A. J. DARNELL. Letter in *J. chem. Phys.*, **21**, 172–3 (*Jan.*, 1953).

The dissociation and the accommodation coeffs. of H_2 and N_2 have been studied by the Langmuir method at 50 microns pressure. For $D(H_2)$ a satisfactory value of 101 ± 3 kcal/mole was obtained. For N_2 no dissociation was detected up to 3300°K.

giving $D(N_2) > 200$ kcal/mole and supporting a spectroscopic value of at least 225. A. G. GAYDON

541.126

2780. Initiation and growth of explosion in liquids and solids. F. P. BOWDEN AND A. D. YOFFE. *Cambridge University Press* (1952) xii + 104 *pp.* and 5 *plates* [Cambridge Monographs on Physics].

Review in *Nature* [*London*] **171**, 186 (*Jan.* 31, 1953).

ELECTROCHEMISTRY 541.13

541.132

2781. The thermodynamics of ionization of some fatty acids. D. H. EVERETT, D. A. LANDSMAN AND B. R. W. PINSENT. *Proc. Roy. Soc. A*, **215**, 403–15 (*Dec.* 5, 1952).

The dissociation constants of the following fatty acids have been determined in water relative to acetic acid over the temperature range 0 to 60°C: propionic, *n*-valeric, *n*-hexoic, *iso*-butyric, *iso*-valeric, *iso*-hexoic, trimethylacetic, diethylacetic. Using Harned's data for acetic acid as standard, the individual dissociation constants have been evaluated. The available data for the fatty acids are analysed to obtain the heat of ionization, and the entropy and heat capacity changes of ionization. These quantities are discussed in relation to the structure of the acid and the orientation of water molecules by the ions. It is concluded that the ions influence the water structure in a volume round the ionic charge of radius about 5Å, and that the effect of the ionic charge on the rigidity of the hydrocarbon chain and on the solvent structure both play an important part in determining the entropy and heat capacity changes. A.

541.132

2782. The dissociation constants of ethylene diammonium and hexamethylene diammonium ions from 0° to 60°C. D. H. EVERETT AND B. R. W. PINSENT. *Proc. Roy. Soc. A*, **215**, 416–29 (*Dec.* 5, 1952).

The two acid dissociation constants of the ethylene diammonium ion and the hexamethylene diammonium ion in water have been determined, using an e.m.f. method, from 0 to 60°C. Measurements have been made at several ionic strengths to allow thermodynamic dissociation constants to be derived, and from these the free energy, heat content, entropy and heat capacity changes accompanying the dissociations have been computed. These quantities are discussed in relation to the size of the diamine molecule, and orientation of solvent molecules by the ionic charges. It is concluded that the range over which a single ionic charge causes a significant change in the structure of liquid water is about 5Å. A.

541.133

2783. On the molecular conductivity of dyestuffs in solution and the influence of foreign substance on the same. K. D. CHAUDHURI AND D. R. DAS GUPTA. *Indian J. Phys.*, **26**, 67–78 (*Feb.*, 1952).

Describes the results of the measurements of the molecular conductivities of dyestuffs in solution. It has been found that in most of the cases the molecular conductivities of dyestuffs in solution do not have linear relations with square root of concentration. The departure of the conductivity curve from the perfect straight line has been explained as due to the formation of ionic micelles. The influence of foreign molecules or ions on the conductivity of the fluorescent dyestuffs in solution has been investigated as well. A.

541.134

2784. Generation of the electrochemical potential on the metal/electrolyte boundary surface. W. LORENZ. *Z. Naturforsch.*, **7a**, 750–2 (*Nov.*, 1952) *In German.*

It is suggested that the force with which the atoms of a metal are bonded to the crystal lattice and to the electrolyte vary from one crystallographic surface plane to another, and, consequently, their chemical potential varies, too. In the macroscopic electrochemical equilibrium state, the density of occupation of sites of the Helmholtz double layer for an infinitely large crystal plane is in equilibrium with the semi-crystalline position. Notwithstanding crystallographic inhomogeneities, a uniform electrode potential exists for a crystal surface, while the exchange between the metallic crystal lattice and the outer layer of the double layer occurs almost exclusively in the growth sites. F. LACHMAN

541.135

2785. Theory of conductivity of strong non-associated electrolytes at high concentrations. H. FALKENHAGEN, M. LEIST AND G. KELBG. *Ann. Phys.* [*Leipzig*] **11**, *No.* 1, 51–9 (1952) *In German.*

A further development of the theories of Onsager, and Debye and Falkenhagen, based on the assumption of the recently proposed [Eigen and Wicke, Abstr. 3967 (1952)] new distribution function which gives the probability of finding an ion *j* in a site *Q* in the neighbourhood of an ion *i* in the site *P*. The application of the generalized theory to the conductivity of NaCl, KCl (and stationary RbCl) solutions and the checking with experimental results has been carried out, and the agreement found to exist up to *c.* 1 mole/litre. F. LACHMAN

541.135

2786. On Bagchi's calculation of activity coefficients by the method of Gronwall and his collaborators. M. DUTTA. Note in *Naturwissenschaften*, **39**, *No.* 24, 569–70 (1952).

Recently Bagchi [Abstr. 9116 (1952)] has calculated activity coefficients by means of the Dutta–Bagchi distribution formula [Abstr. 7559 (1950)], which is corrected for the volume actually occupied by the water molecules, and then applied to the method of Gronwall, La Mer and Sandved (1928). This application is shown to be unjustified, and it is pointed out that good agreement is obtained between observed and calculated activity coefficients by use of Dutta's formula [Abstr. 5380 (1952)] without introduction of the above correction. H. H. HODGSON

541.135 : 539.217

The transmission of hydrogen through palladium by electrolysis. *See Abstr.* 2752

541.135.5

2787. pH response of nonhygroscopic glasses. R. G. GOLDMAN AND D. HUBBARD. *J. Res. Nat. Bur. Stand.*, **48**, 370–6 (*May*, 1952).

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

2788. The effect of 1470Å irradiation of nitrogen-hydrogen mixtures and of ammonia. M. H. J. Wijnen and H. A. Taylor. *J. chem. Phys.*, **21**, 233–6 (*Feb.*, 1953).

The characteristics of a Xe resonance lamp were studied, using CO_2 as an actinometer, to determine the influence of the Xe pressure in the lamp on the intensity of the 1470Å radiation. The Xe sensitized photosynthesis of ammonia was studied both in static and in flow systems. No ammonia could be detected. Some experiments on the photolysis of ammonia at 1470Å are reported and discussed. The present work furnishes the first direct chemical evidence rejecting the value of 171·3 kcal per mole as the dissociation energy of N. A.

541.15

2789. Effect of high-energy radiation on long-chain polymers. A. Charlesby. Letter in *Nature* [*London*] **171**, 167 (*Jan.* 24, 1953).

When subjected to high energy radiation some polymers, e.g. Polythene, polystyrene, Terylene, Nylon and unvulcanized rubber, become cross-linked, the degree of cross-linking being proportional to the radiation dose. The physical changes accompanying the progressive cross-linkage of Polythene are described. Chemical changes, e.g. emission of hydrogen and small amounts of methane, ethane, etc., and surface oxidation, also occur. Changes in density during irradiation of Polythene have been investigated and correlated with degree of cross-linking and other properties. C. B. Allsopp

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.18.043

2790. An ultracentrifuge cell for producing boundaries synthetically by a layering technique. E. G. Pickels, W. F. Harrington and H. K. Schachman. *Proc. Nat. Acad. Sci. U.S.A.*, **38**, 943–8 (*Nov.*, 1952).

An illustrated description of a special cell designed and built to enable boundaries between a solution containing only the fast-sedimenting component and a mixture of the first solution plus some quantity of the slow-sedimenting component, being stabilized in the centrifugal field, when layering technique is used. The use of the cell in the study of mixtures in the ultracentrifuge is also described, and its application to the study of the sedimentation of small molecules and to other ultracentrifuge problems is discussed.

F. Lachman

541.182.025 : 532.13

2791. Effect of shear temperature on viscosity in a rotational viscometer measurement. R. N. Weltmann and P. W. Kuhns. *J. Colloid Sci.*, **7**, 218–26 (*June*, 1952).

A method is described which permits determination of the approximate temperature distribution over the cross-sectional area of a Newtonian material which is subjected to shearing forces in a rotational viscometer. By correlating the change of viscosity to temperature increases, and by determining the actual viscosity value as found in the rotational viscometer, the effect of thixotropy can be studied. Temperature calculations with regard to an Oronite polybutylene oil and a silicone fluid have been made, in each case for various operational conditions of a rotational viscometer. It appears that in some instances where previously the presence of thixotropy was suspected, temperature increases might be responsible for viscosity breakdown. In other instances thixotropic behaviour must still be postulated to explain the experimental results. A.

541.182.3

2792. An instrument for determining the electric charge distribution in aerosols. T. Gillespie and G. O. Langstroth. *Canad. J. Chem.*, **30**, 1056–68 (*Dec.*, 1952).

An instrument has been developed to permit measurement of the electric charges on a relatively large number of particles during a comparatively short period in the history of an aerosol. These novel characteristics have been obtained by depositing a sample on microscope slides in such a way that the charge on any particle at deposition can be determined in a subsequent examination from the size of the particle and its position on the slide. There is evidence to show that the act of sampling with this instrument does not cause spurious charging of particles. The construction and theory of the instrument are described in some detail and results of tests are given to show that the theory is applicable. The use of the instrument is illustrated by an account of a preliminary study of the charge distribution in a silica dust aerosol at various times after generation.

541.182.6 : 537.531 : 535.42

2793. Size determinations of clay particles in water suspensions by use of low-angle X-ray diffraction. W. J. West. *J. Colloid Sci.*, **7**, 295–305 (*June*, 1952).

Change in the state of the suspension can be made, and sizes of the particles can be determined again as they exist in the new state. Particle-size determinations by other methods do not share this advantage. Supercentrifugal size analysis must be made with sample at high dilutions, and electron microscope size analysis must be made with sample in the dry state. The two-crystal X-ray spectrometer designed and built by Professor J. W. M. DuMond at the California Institute of Technology was used to measure the low-angle X-ray diffraction from clay-water suspensions. From these measurements, particle sizes were determined. Particle size determinations on several clays that are used as drilling fluids in the petroleum industry showed: (*a*) The size of hydrated clay particles in water suspension was larger than the size of the particles in the original dry powdered clay (approx. 0·3 μ). The increase in size was proportional to the clays' swelling abilities. This observation contradicts the common belief that highly swelling clays have smaller particles in water suspensions than poorly swelling clays. (*b*) Sizes of the hydrated

particles in water suspensions were independent of dilution for concentrations less than 8%. (c) Viscosity lowering by agents such as tetrasodium pyrophosphate involved size reduction of hydrated particles. A.

541.183

2794. A study of adsorption hysteresis by means of length changes of a rod of porous glass. C. H. Amberg and R. McIntosh. *Canad. J. Chem.*, **30**, 1012–32 (*Dec.*, 1952).

From adsorption data and measurements of length changes of a porous glass rod, a qualitative description of the processes involved in the adsorption of water vapour is developed. Particular attention is devoted to the causes of the hysteresis loop. The qualitative theory appears to be useful in understanding the adsorption of water on charcoal, and may therefore be of value in interpreting the phenomenon of limited hysteresis on any porous adsorbent. Three attempts to test the theory quantitatively are presented. These involve the computation of surface areas, of Young's moduli, and of isoteric heats of adsorption. The quantitative treatment also leads to an estimate of the total number of pores and the mean length of the pores, in addition to the pore radius. Such an assessment of a porous structure has apparently not been possible earlier. A.

541.183 : 536.423.8

2795. A new apparatus for studying the evaporation of water through monolayers. F. Sebba and N. Sutin. *J. Chem. Soc.*, **1952**, 2513–16 (*July*).

An apparatus has been developed for investigating the effect of monolayers on the rate of evaporation of water into an atmosphere at low pressure. The technique, which has proved more sensitive than earlier methods, has revealed that the critical surface pressure at which the resistance to evaporation of stearic acid first becomes appreciable is very close to the surface pressure at which the film becomes relatively incompressible. On the other hand, a film of cholesterol, though it becomes incompressible at very low surface pressures, does not affect the rate of evaporation of the substrate. A.

541.183 : 536.424

2796. Phase transitions in multimolecular layers of adsorbed nitrogen. J. A. Morrison, L. E. Drain and J. S. Dugdale. *Canad. J. Chem.*, **30**, 890–903 (*Nov.*, 1952).

The heat capacity of nitrogen adsorbed on titanium dioxide has been measured for amounts adsorbed corresponding to 2·2, 3·1, 4·0 and 4·8 molecular layers in the temperature range 14° to 75°K. The occurrence in the adsorbed films of melting and of the transition in the solid phase of nitrogen is shown by maxima in the heat capacity. The melting process is completely reversible and takes place at temperatures below the normal melting point. The solid phase transition does not occur reversibly, the magnitude of the anomaly in the heat capacity depending upon the extent to which the system has been cooled prior to the measurement of the heat capacity. The experimental results are discussed in terms of current thermodynamic treatments of phase transitions in adsorbed films. A.

CHEMICAL STRUCTURE 541.2/.6

541.41

2797. On the stability of metallo-organic compounds. H. H. Jaffé and G. O. Doak. *J. chem. Phys.*, **21**, 196–200 (*Feb.*, 1953).

It is pointed out that serious difficulties are encountered in preparing organic compounds of the transition elements. The hypothesis is proposed that these difficulties are caused by insufficient stability of the carbon–metal bonds involved. Some rough calculations based on Mulliken's "magic formula" are used to test this hypothesis. The results obtained indicate that carbon–metal bonds formed by the transition elements are extremely weak. The calculations further suggest that carbon–metal bonds involving the alkali and alkaline earth metals are largely ionic. A.

541.57 : 548.0

2798. Strong hydrogen bonds in crystals. R. C. Lord and R. E. Merrifield. Letter in *J. chem. Phys.*, **21**, 166–7 (*Jan.*, 1953).

The OH-stretching frequencies have been investigated for a number of organic acids, potassium phosphate and sodium bicarbonate. The $N^+–H\cdots X^-$ bond in tertiary amine hydrohalides has been investigated. The effect of deuterium substitution is shown in a table. It is suggested that a quantum-mechanical model of the hydrogen bond is needed. C. Turner

541.64 : 519.2 : 535.43

2799. The statistics of stiff chains, with applications to light scattering. J. J. Hermans and R. Ullman. *Physica*, **18**, 951–71 (*Nov.*, 1952).

When the directions of successive steps of a path in space are correlated, the position of the endpoint of a path of given length will show correlation with the orientation at this endpoint. The present paper deals with the limiting case in which the length of the steps approaches zero. Using the method introduced by Kramers (1940) in the theory of Brownian movement, a differential equation is set up for the distribution of positions and orientations. It is shown that the result is in conformity with that derived by Daniels (1952) who used a different method and eliminated the orientation from the very beginning. The Laplace transform of the intensity of the light scattered in a given direction is derived, and it is shown that the asymptotic result for very long chains is identical with that derived by previous authors for Gaussian chains, while that for very short chains is the same as the result for stiff rods. Formulae are also derived for the intensity of the light scattered by optically anisotropic chains, where the correlation between position and orientation is a decisive factor. The relation between the intensity of the light and the angle of scattering is shown to depend on the optical anisotropy of the chains, except at the limit of very long chains, as was to be expected. Attention is drawn to the fact that the model should be applicable also to certain problems concerned with the scattering of nuclear particles. A.

541.64 : 534.22/.23

Ultrasonic-wave study of swollen Buna-N rubber. *See Abstr.* 2263

CHEMICAL PROCESSES 542.9

542.943

2800. The inhibiting effect of lead tetraethyl. II. The effect of lead monoxide on the slow oxidation of methane. D. E. Hoare and A. D. Walsh. *Proc. Roy. Soc. A*, **215**, 454–66 (*Dec.* 22, 1952).

For Pt I, see Abstr. 2004 (1953). Experiments on the slow oxidation of methane in PbO-coated vessels are described. Relative to the behaviour in a new or "HF-treated" Si vessel, the PbO coating causes (1) comparatively little effect on the induction period to the onset of a marked rate of pressure rise, but a very marked diminution of the maximum rate of pressure rise; (2) at temperatures near 500°C a rise in over-all activation energy of the maximum rate of pressure rise from *c.* 25 to *c.* 58 kcal/mole; (3) a small increase in the dependence of the maximum rate of pressure rise upon the total initial pressure. It is shown that effects (1) and (2) are due to the suppression by a PbO coating of the "degenerate branching" normally introduced into the oxidation of methane by the secondary oxidation of the formaldehyde formed as an intermediate product. The conclusion is reached that this suppression is probably due to efficient destruction by the PbO surface of HO_2 (and perhaps HCO_3) radicals, though under other experimental conditions a PbO surface may destroy other species of chain carriers. Incidental deductions are that H and O atoms and OH radicals do not play an important role in the secondary, formaldehyde oxidation, chains; and therefore that certain reactions proposed for the initiation of the formaldehyde oxidation chains are incorrect. A.

CHEMICAL ANALYSIS 543/545

545–3

2801. Anomalous adjustment of indicator concentration in moving boundary measurements of transference numbers. A. R. Gordon and R. L. Kay. *J. chem. Phys.*, **21**, 131–5 (*Jan.*, 1953).

If in a measurement with a rising boundary, the initial concentration of the indicator solution is greater than the critical Kohlrausch concentration, it has long been known that the concentration of the column of solution formed behind the boundary will have the Kohlrausch value, i.e. there is downward adjustment of indicator concentration. It is here shown that if the initial indicator concentration be less than the Kohlrausch concentration, there can be upward adjustment of concentration. Similarly, with a falling boundary, there can be downward adjustment if the initial indicator concentration be greater than the Kohlrausch value. A mechanism for the adjustment process is proposed, and it is shown that the reason such anomalous adjustment is effective, is the extreme slowness of mixing under a density gradient in narrow channels. The significance of these results for moving boundary measurements is discussed, and a simple method is described for determining the adjusted indicator concentration with reasonable precision. A.

545.822

2802. The influence of varying amounts of elements in steel and cast irons on spectral intensity. L. J. Canody, T. Harris, Jr and J. F. Woodruff. *J. Opt. Soc. Amer.*, **43**, 145–9 (*Feb.*, 1953).

The effect upon spectral intensity of varying amounts of elements in approximately sixty Bureau of Standards steel samples have been investigated. Samples used in the study included cast iron, low and high carbon steels and low and high alloy steels. Of all the certified analyses, only varying amounts of C, Cr and P appeared to affect spectral intensity. Experimental data and spectrochemical techniques are discussed. A.

CRYSTALLOGRAPHY 548

548.24

2803. Accommodation kinking associated with the twinning of zinc. A. J. W. Moore. *Proc. Phys. Soc. [London] B*, **65**, 956–7 (*Dec.*, 1952).

Small changes of slope on cleavage surfaces of zinc single crystals have been measured by a stylus type profile recorder (Talysurf) and compared with photomicrographs of the same areas. Lattice bending through angles up to approximately 0° 47′ which relieves the localized shearing stresses due to twinning has been observed. Other examples show firstly one twin with two associated accommodation kinks, and secondly a twin and its associated kink band occurring within the kink band associated with a second parallel twin. A.

548.5

2804. Synthesis of mica. A. Van Valkenburg and R. G. Pike. *J. Res. Nat. Bur. Stand.*, **48**, 361–9 (*May*, 1952).

A synthetic fluorophlogopite mica ($KMg_3AlSi_3O_{10}F_2$), in which the (OH) ions that are normally found in normal micas were completely replaced by fluorine, has been synthesized. This material has essentially the same physical and electrical properties as natural phlogopite mica, except with somewhat lower flexibility. To grow large, usable sheets of mica, it is necessary to obtain preferred crystal orientation, which depends primarily on controlled thermal gradients, batch composition and rate of cooling. Platinum crucibles were found to be the best material for holding the batch during the melt. Data on the physical, electrical, thermal and chemical properties of the synthetic mica are given. A.

548.5

2805. Orientation studies of exaggerated grain growth in tungsten. F. D. Rosi. *Sylvania Technol.*, **5**, 82–6 (*Oct.*, 1952).

The studies were made on tungsten wires doped with alumina. They showed that the resulting coarse grains have a preferred orientation in which a <531> orientation coincides with the specimen axis. Measurements on the reaction rate of the

exaggerated growth transformation were made at 2200°c by measuring the fraction of the wire transformed for various times. The results of these measurements suggest that this growth process can be described in terms of nucleation and growth rates. On the basis that the exaggerated growth process in these wires is orientation-dependent, some theoretical considerations have been advanced on the origin of these coarse grains and the effect of impurities at grain boundaries. A.

548.5

2806. A note on oriented crystalline overgrowth. M. BLACKMAN. *Proc. Phys. Soc.* [*London*] *A*, **65**, 1040–3 (*Dec.*, 1952).

A brief review is given of experimental results on the oriented overgrowth of very thin deposits of alkali halides evaporated on to cleavage surfaces. The theoretical implications of some of these results are considered. A.

548.5

2807. Growth spirals originating from screw dislocations on electrolytically produced titanium [single] crystals. M. A. STEINBERG. Letter in *Nature* [*London*] **170**, 1119–20 (*Dec.* 27, 1952).

Multiple spirals centred on dislocations observed on the flat (0001) basal plane are illustrated and discussed. The average step height was 240 ± 100 Å. Spirals of opposite sign, interacting to form closed loops, were also observed. In all cases the spirals became hexagonal in shape following the crystal outline. S. WEINTROUB

548.5

2808. Spiral patterns on salocrystals. S. AMELINCKX. Note in *Naturwissenschaften* **39**, *No.* 23, 547 (1952).

Growth spirals observed by reflection microscopy on crystals prepared by slow evaporation of a solution of the organic compound, salol, in benzene or CCl_4 are very briefly reported and illustrated. Polygonization is mainly complete. The step height is estimated to be several hundred angströms. Spirally terraced pits, unexplained by theory, on large (±1 mm) and thick crystals were observed. These pits are associated with radially oriented discontinuities which are apparently cracks. S. WEINTROUB

548.5

2809. Purification and prevention of segregation in single crystals of germanium. W. G. PFANN AND K. M. OLSEN. Letter in *Phys. Rev.*, **89**, 322 (*Jan.* 1, 1953).

The crystals were refined until the excess donor concentrations were less than 5×10^{12} atoms-cm^{-3} by passing a molten zone along the length of the crystal. This technique can be used to prevent solute segregation along the freezing direction in doped crystals.

W. BARDSLEY

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

2810. Imperfections in nearly perfect crystals. J. J. MARKHAM. *New York, John Wiley* (1952) 490 + xii *pp.*

Review in *J. Opt. Soc. Amer.*, **42**, 985 (*Dec.*, 1952).

548.7

2811. A combinatorial solution of the two-dimensional Ising model. M. KAC AND J. C. WARD. *Phys. Rev.*, **88**, 1332–7 (*Dec.* 15, 1952).

An elementary method which yields the partition function of a two-dimensional Ising model is described. The method is purely combinatorial and does not involve any of the algebraic apparatus used in this connection by Onsager and Kaufman [Abstr. 2722 (1950)]. A.

548.7

2812. *F*-bands in some mixed crystals of the alkali halides. R. J. GNAEDINGER, JR. *J. chem. Phys.*, **21**, 323–30 (*Feb.*, 1953).

X-ray induced *F*-bands in melt-grown mixed crystals of KCl and RbCl were studied. Though no resolution of "component" *F*-bands was obtained at liquid nitrogen temperature, the behaviour of the *F*-band parameters as a function of concentration of RbCl in KCl and as a function of temperature is shown to be explainable by postulating the existence of a set of "component" *F*-bands, each arising from an *F*-centre with a given composition of positive ions immediately surrounding it. Some studies of other mixed crystals are also mentioned. A.

548.7 : 539.132

Localized functions in molecules and crystals. *See Abstr.* 2589

548.73/.74

2813. The determination of interatomic distances by X-ray and electron diffraction. J. WYART. *Cahiers de Phys., No.* 40, 1–16 (*Nov.*, 1952) *In French.*

A review of techniques and methods. J. THEWLIS

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr*, 2757–62

548.733

2814. Apparatus permitting the direct photography of reciprocal space. A. RIMSKY. *Bull. Soc. Franç. Minéral. Crist.*, **75**, 500–5 (*Oct.–Dec.*, 1952) *In French.*

Describes an apparatus by which a previously chosen plane in reciprocal space may be photographed. The photographic plate rotates in synchronism with the crystal, the two axes of rotation being parallel and the plate being above the crystal as in the de Jong and Bouman method. The inclination of these axes to the X-ray beam is a matter of choice. A diaphragm is incorporated for selecting any desired layer in the reciprocal lattice. J. THEWLIS

548.733

2815. Universal mountings for X-ray goniometers. K. A. GROSS. Letter in *J. sci. Instrum.*, **29**, 414 (*Dec.*, 1952).

To measure crystal repeat distances at right angles to the axis of the goniometer on which the crystal is mounted, an L-shaped bracket is interposed between the fibre bearing the crystal and the arcs.

A. L. MACKAY

548.733

2816. A spiral-scanning X-ray reflection goniometer for the rapid determination of preferred orientations. A. N. HOLDEN. *Rev. sci. Instrum.*, **24**, 10–12 (*Jan.*, 1953).

A goniometer has been designed to rapidly scan

polycrystalline metal samples along a spiral path in a stereographic projection, and which, when used with any recording counting-rate meter available on a modern X-ray spectrometer, enables the rapid determination of the preferred crystal orientations of the sample. A.

548.735

2817. The probability distribution of the magnitude of a structure factor. I. The centrosymmetric crystal. J. KARLE AND H. HAUPTMAN. *Acta cryst.*, **6**, 131–5 (*Feb.*, 1953).

The general formula for the probability distribution of the structure factor is derived for all rigid centrosymmetric crystals as a function of the indices h, k, l. The distributions and the averages of any power of $|F|$ corresponding to a particular space group may be obtained from the general formula by means of routine mathematical computations. The analysis includes the case that the crystal contains atoms in special positions as well as in general positions. Illustrative examples are worked out in detail. A.

548.735

2818. The probability distribution of the magnitude of a structure factor. II. The non-centrosymmetric crystal. H. HAUPTMAN AND J. KARLE. *Acta cryst.*, **6**, 136–41 (*Feb.*, 1953).

The general formula for the compound probability distribution of the real and imaginary parts of the structure factor is derived for all rigid non-centrosymmetric crystals as a function of the indices h, k, l. The probability distribution for the magnitude of the structure factor is then readily found. The distributions and the averages of any power of $|F|$ corresponding to a particular space group may be obtained from the general formula by means of routine mathematical computations. The analysis includes the case that the crystal contains atoms in special positions as well as in general positions. Illustrative examples are worked out in detail. A.

548.735

2819. Determination of a crystal structure when the positions of some of the atoms are known: statistical treatment. V. LUZZATI. *Acta cryst.*, **6**, 142–52 (*Feb.*, 1953) *In French.*

A statistical method has been applied to develop the relation between the electron density and a function $\rho'(\mathbf{r})$ calculated with the moduli of the structure factors corresponding to all the atoms in the unit cell of a crystal and with phase angles corresponding to only some of these atoms. Both centrosymmetrical and non-centrosymmetrical cases are considered and a criterion is proposed which makes it possible to predict whether or not the positions of all the atoms in a structure can be determined when the positions of some of them are known. A.

548.735

2820. A statistical treatment of superlattice reflections. A. L. MACKAY. *Acta cryst.*, **6**, 214–15 (*Feb.*, 1953).

By considering the ratio of the intensities of weak superlattice reflections to those of ordinary reflections, averaged over limited ranges of Bragg angle, an estimate has been obtained for the r.m.s. magnitude of the atomic displacements from the pseudo-structure which give rise to the weak reflections. A.

548.735.7

2821. X-ray study of the dimensions of the reflecting regions [domaines de Bragg] in polycrystalline powders. I. E. F. BERTAUT. *Bull. Soc. Franç. Minéral. Crist.*, **75**, 527–53 (1952) *In French.*

An account (largely a review) of the theory of methods of determining mean crystallite size and distribution of crystallite sizes from X-ray line profiles. The correction of line widths and profiles is discussed, and also the effect on X-ray lines of lattice distortion in metals. A. R. STOKES

548.736.3

2822. On the crystal structure of fluorides of the tysonite or LaF_3 type. K. SCHLYTER. *Ark. Kemi*, **5**, *Paper* 8, 73–82 (1952).

Weissenberg photographs of tysonite show that the true cell has $a \sim 4{\cdot}1$, $c \sim 7{\cdot}3$ Å, $Z = 2$, space group $C6/mmc$, 2(La, Ce) in (c), 2F in (b) and 4F in (f) with $z = 0{\cdot}57 \pm 1$. Previous reports of a larger cell with $a \sim 7{\cdot}1$, $c \sim 7{\cdot}3$ Å were probably due to contamination of the powder samples with bastnäsite. Pure LaF_3 has $a = 4{\cdot}148$, $c = 7{\cdot}354$ Å. A. J. C. WILSON

548.736.3

2823. The crystal structure of NaPb. R. E. MARSH AND D. P. SHOEMAKER. *Acta cryst.*, **6**, 197–205 (*Feb.*, 1953).

The crystal structure of the intermetallic compound NaPb has been determined by X-ray diffraction methods, with use of both single-crystal and powder specimens. The structure is tetragonal, with space group D_{4h}^{20}–$I4/acd$, and with lattice constants $a_0 = 10{\cdot}580$ Å and $c_0 = 17{\cdot}746$ Å at room temperature. The 32 lead atoms in the unit cell (in 32(g): $x = 0{\cdot}0696$, $y = 0{\cdot}1186$, $z = 0{\cdot}9383$; . . .; with respect to an origin taken at a centre of symmetry) form eight nearly-regular Pb_4 tetrahedra with Pb–Pb bond-lengths of 3·15 and 3·16 Å; the 32 sodium atoms (16 in 16(e): $\frac{1}{4}$, y, $\frac{1}{2}$; . . .; $y \sim \frac{1}{8}$; and 16 in 16(f): x, $x + \frac{1}{4}$, $\frac{5}{8}$; . . .; $x \sim \frac{1}{8}$; origin as above) are arranged in shells about the Pb_4 tetrahedra, with Pb–Na bond-lengths averaging about 3·48 Å and Na–Na bond-lengths averaging about 3·72 Å. The shell of sodium atoms enclosing each Pb_4 tetrahedron contains 16 sodium atoms, each of which belongs also to shells surrounding other Pb_4 tetrahedra. From the observed bond-lengths the valence of lead in NaPb appears to be about 3·0 and that of sodium about 1·5, there being apparently some electron transfer from lead to sodium. A.

548.736.3

2824. The crystal structure of cesium hexasulfide. S. C. ABRAHAMS AND E. GRISON. *Acta cryst.*, **6**, 206–13 (*Feb.*, 1953).

CsS_6 forms triclinic crystals, space group $P\bar{1}$, with two molecules in the unit cell of dimensions $a = 11{\cdot}53$, $b = 9{\cdot}18$, $c = 4{\cdot}67$ Å, $\alpha = 89° 13'$, $\beta = 95° 12'$ and $\gamma = 95° 8'$. The crystal structure has been completely determined, the positional parameters being refined by double Fourier series based on 382 terms derived from visual intensity measurements. The Cs atoms are completely ionized, and the resulting hexasulphide ion is shown to be non-

branched and non-planar. The average S–S–S angle is 108·8°. Two kinds of S–S bond exist, of length 2·02 and 2·11 Å, alternately arranged along the hexasulphide chain. The dependence of the S–S bond distance upon the amount of double-bond character is similar to the C–C relationship. The crystal is characterized by the van der Waals contacts of 3·39 Å between the ends of neighbouring hexasulphide ions which form infinite helices of sulphur atoms. A.

548.736.3 : 538.221

2825. Crystal structure and antiferromagnetism in haematite. B. T. M. Willis and H. P. Rooksby. *Proc. Phys. Soc.* [*London*] *B*, **65**, 950–4 (*Dec.*, 1952).

The crystal structure of haematite has been investigated by X-ray analysis in the temperature range 20°c to 950°c. On cooling through a temperature of approximately 675°c the rhombohedral unit cell undergoes a sudden expansion along the triad axis direction. The results are interpreted in terms of an antiferromagnetic behaviour of pure haematite, with a Curie point at approximately 675°c. It is shown that the behaviour is analogous to that of the cubic oxides FeO and Fe_3O_4, which exhibit structure cell deformations on cooling through certain critical temperatures. A.

548.736.3 : 539.185

2826. The lattice expansion of quartz due to fast neutron bombardment. M. Wittels. Letter in *Phys. Rev.*, **89**, 657 (*Feb.* 1, 1953).

Under the influence of fast neutron bombardment quartz is found to expand anisotropically and corresponding changes in density are noted. A total integrated neutron flux of $6{\cdot}6\times10^{19}$ causes an expansion of a_0 from 4·903 to 5·01 Å and of c_0 from 5·393 to 5·41 Å. X-ray line broadening is also observed, and it is concluded that lattice distortion is present. The effects may be annealed out by suitable heat treatment. J. THEWLIS

548.736.4

2827. The crystal chemistry of the Laves phases. R. L. Berry and G. V. Raynor. *Acta cryst.*, **6**, 178–86 (*Feb.*, 1953).

The $C_{14}(MgZn_2)$, $C_{15}(MgCu_2)$ and $C_{36}(MgNi_2)$ crystal structures frequently occur at the composition AB_2 in alloy systems for which the ratio of the atomic radii of the components is approximately 1·2. In certain ternary magnesium alloys interesting structural changes from one type to another occur as other metals are substituted for zinc and copper in $MgZn_2$ and $MgCu_2$ respectively. In an attempt to understand these changes, and the factors determining which of the closely related structures is assumed in a given case, an examination has been made of the interatomic distances in phases for which data are available. A parameter S which measures the deviation of particular interatomic distances (d_{AA} or d_{BB}) from the corresponding distances in the pure components (d_A or d_B) is plotted against $W = d_A/d_B$. For series of phases with common A or B components, the relationship between W and S is approximately linear. If W lies close to the ideal value for the formation of a Laves phase, S is small, and hexagonal C_{14} structures occur. As W deviates from the ideal value, S increases numerically, and cubic C_{15} structures occur. This suggests that, for a given series of phases with common A or B components, the C_{14} structure is not in general stable above or below a critical W value. When the B component is a transitional metal, more complex graphs are obtained; there is evidence in these cases for relatively strong A–B interactions. Assuming that increasing S favours the C_{15} structure, and taking into account the effect of changing Fermi energy, an interpretation of the structural changes observed in ternary magnesium alloys is possible. The considerations outlined in this paper should help in the prediction of Laves phases in alloy systems as yet not investigated. A.

548.736.4 : 539.164.9

2828. Alpha-radiation damage in zircon. P. M. Hurley and H. W. Fairbairn. Letter in *J. appl. Phys.*, **23**, 1408 (*Dec.*, 1952).

This arises from U or Th impurities in naturally occurring zircon. The total α-bombardment may be calculated from the geologically determined age and the present α-activity, and for a large number of samples examined was found to be closely related to the X-ray diffraction angle from the (112) plane, which therefore provides a convenient measure of the damage. It is estimated that $4{\cdot}5\times10^3$ atoms are displaced per α-track, a figure which suggests that structural damage is produced only by knock-on atoms at the ends of α-tracks and by the recoil parent atom. Other evidence supports this. A. D. LE CLAIRE

548.736.5

2829. The crystal structure of $MnCl_2.2H_2O$. B. K. Vaĭnshteĭn. *Dokl. Akad. Nauk SSSR*, **83**, *No.* 2, 227–30 (1952) *In Russian.*

Single crystal electronograms were obtained for the *hk*0, *h*01 and *hh*1 zones and powder and texture photographs were also taken. From these $MnCl_2.2H_2O$ appeared isomorphous with $CoCl_2.2H_2O$ [Abstr. 2794 (1950)]. Cell dimensions are $a = 7{\cdot}403 \pm 0{\cdot}01$, $b = 8{\cdot}770 \pm 0{\cdot}005$, $c = 3{\cdot}701 \pm 0{\cdot}005$ Å (?) with $\beta = 98°\,05'$. The space group is $C2/m$. From the 120 measured reflections a Fourier section at $y = 0$ and a line at $x = y = 0$ gave the atomic parameters: Mn at 000, $\frac{1}{2}\frac{1}{2}0$; Cl in the mirror plane with $x = 0{\cdot}246$ and $z = 0{\cdot}563$; H_2O on the diad axis with $y = 0{\cdot}250$. A. L. MACKAY

548.736.5

2830. The structure of the 9(18)-heteropoly anion in potassium 9(18)-tungstophosphate, $K_6(P_2W_{18}O_{62}).14H_2O$. B. Dawson. *Acta cryst.*, **6**, 113–26 (*Feb.*, 1953).

The structure of the 9(18)-heteropoly-anion in potassium 9(18)-tungstophosphate has been determined by X-ray analysis, employing two-dimensional methods. The crystals are triclinic with $a = 12{\cdot}86$, $b = 14{\cdot}83$, $c = 22{\cdot}34$ Å, $\alpha = 94°\,24'$, $\beta = 116°\,52'$, $\gamma = 115°\,36'$. The space group is $P\bar{1}$, and the unit cell contains two units of empirical formula $3\,K_2O.P_2O_5.18\,WO_3.14\,H_2O$. Complete analyses of the *a*- and *b*-axis Patterson projections show the tungsten framework of the 9(18)-anion to be a layer structure consisting of four rings of atoms, the end two triangular and the central two almost perfectly hexagonal. By comparison of the tungsten frame-

work of the 9(18)-anion with that of the 12-tungstophosphate anion $(PW_{12}O_{40})^{3-}$ it is shown that the complete 9(18)-anion has the formula $(P_2W_{18}O_{62})^{6-}$. The anion is a complex co-ordinated structure, of point group symmetry $3/m$, in which the tungsten and phosphorus atoms are surrounded by octahedra and tetrahedra of oxygen atoms respectively. A.

548.736.5

2831. Crystal structure of $HNO_3.3H_2O$. I. Determination of the structure, utilization of the Patterson function. V. Luzzati. *Acta cryst.*, **6**, 152–7 (*Feb.*, 1953) *In French.*

$HNO_3.3H_2O$ is orthorhombic with space group $P2_12_12_1$. The structure has been determined by the quantitative interpretation of a three-dimensional modified Patterson function. Atomic co-ordinates have been refined by repeated Fourier projections and an example is given of the systematic application of the difference $|F_o| - |F_c|$ to determine the mean error in the atomic positions. An example is also given of a case in which repeated Fourier projection converged to incorrect atomic positions. A.

548.736.5

2832. Crystal structure of $HNO_3.3H_2O$. II. Localization of the hydrogen atoms; discussion of errors; description of the structure. V. Luzzati. *Acta cryst.*, **6**, 157–64 (*Feb.*, 1953) *In French.*

The projection $\rho(x, y)$ has been studied in detail, using the functions $\rho_o - \rho_c$, and the hydrogen positions have been determined. Each hydrogen atom is situated between two oxygen atoms, being nearer to one than to the other. The arrangement of hydrogen atoms round the oxygen atom of one of the three water molecules is analogous to that found in ice. The oxygen atom of the second of the water molecules exchanges three hydrogen bonds and two hydrogen atoms are attached to it. The oxygen atom of the third water molecule has three hydrogen atoms, a configuration corresponding to the ion OH_3^+. The role of the hydrogen bonds in the structures of anhydrous and hydrated nitric acids is discussed. A.

548.736.5

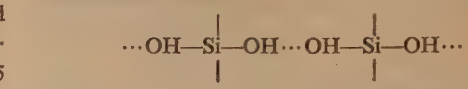
2833. The crystal structures of two potassium sodium chloride dithionates. E. Stanley. *Acta cryst.*, **6**, 187–96 (*Feb.*, 1953).

The preparation of two mixed salts, $NaK_3Cl_2(S_2O_6)_2$ and $NaK_2Cl(S_2O_6)$, is described. The space groups are $P4/mnc$ and $P4/n$ respectively. The two structures are very similar and by suitably reorientating the unit cells the similarities can be emphasized. This is used to explain the tendency of the two to grow together in an apparently single crystal, and the occurrence of mistakes observed in some specimens. The size and shape of the dithionate ion has been determined: the interatomic distances are S–S 2·08 Å, S–O 1·48 Å, O . . . O 2·46 Å, in confirmation of earlier determinations. A.

548.736.6

2834. Crystal structure of diethylsilanediol and its hydroxyl groups. M. Kakudo and T. Watase. Letter in *J. chem. Phys.*, **21**, 167–8 (*Jan.*, 1953).

Colourless flat monoclinic holohedral crystals having space-group C_{2h}^5—$P2_{1/a}$. The crystal consists of molecular chains



parallel to the b axis. A figure shows the arrangement of the —OH groups. The interatomic distances and bond angles are given. C. TURNER

548.737

2835. *Bis-cyclo*pentadienyl iron: a molecular sandwich. J. D. Dunitz and L. E. Orgel. Letter in *Nature* [*London*] **171**, 121–2 (*Jan.* 17, 1953).

X-ray evidence is given in favour of the structures proposed by Woodward *et al.* [*J. Amer. Chem. Soc.*, **74**, 2125 (*April* 20, 1952)] for the *bis-cyclo*pentadienyl iron molecule. The possible stability of similar compounds containing other transition metals is predicted. G. I. W. Llewelyn

548.737

2836. The crystal structure of formic acid. F. Holtzberg, B. Post and I. Fankuchen. *Acta cryst.*, **6**, 127–30 (*Feb.*, 1953).

The crystal structure of formic acid has been determined at −50 ± 5°C, using single-crystal X-ray diffraction techniques. The unit cell is orthorhombic with $a = 10{\cdot}23 \pm 0{\cdot}02$, $b = 3{\cdot}64 \pm 0{\cdot}01$ and $c = 5{\cdot}34 \pm 0{\cdot}01$ Å. There are four molecules per unit cell. The space group is *Pna*. Bond lengths have been determined using Fourier projections on (010) and (001). The C–O bond length is $1{\cdot}26 \pm 0{\cdot}03$, C = O $1{\cdot}23 \pm 0{\cdot}03$ Å and the O–C = O angle $123 \pm 1°$. The molecules are arranged in the form of infinite chains in the crystal, each molecule being linked to two neighbours by hydrogen bonds. The length of the hydrogen (O–H . . . O) bond is $2{\cdot}58 \pm 0{\cdot}03$ Å. A.

548.74 : 537.533.73

2837. The theory of electron diffraction. R. Glauber and V. Schomaker. *Phys. Rev.*, **89**, 667–71 (*Feb.* 15, 1953).

It is shown that the omission of an angle-dependent phase factor in the scattering amplitude constitutes a significant error of the Born approximation, as customarily applied to electron diffraction experiments. Some general properties of the scattering amplitude are discussed in relation to the Born approximation and used to derive a simple estimate of the required phase. The theory, thus corrected, is found to remove the need for assuming rather distorted structures in some molecules containing heavy atoms. The effect discussed is present quite generally in the interference of waves scattered by differing potentials and becomes more prominent as the particle energy is lowered. In the appendix a semiclassical procedure is used to treat the analogous effect in proton diffraction. A.

GEOPHYSICS 55

550.385

2838. One particular characteristic of the geographical distribution of the field of a magnetic storm. V. I. AFANASEVA AND YU. D. KALININ. *Dokl. Akad. Nauk SSSR*, **82**, *No.* 3, 379–80 (1952) *In Russian.*

The storm-time-variation D_{st} for the horizontal component H was determined for 10 observatories disposed at geomagnetic latitudes ϕ from 32–72° in the course of 11 years. In addition to the basic relation between D_{st} and ϕ, viz. the gradual increase in the absolute value of D_{st} with ϕ, another phenomenon was observed. On the background of the normal relation between D_{st} and ϕ at latitudes 50–70°, there was observed a secondary max. for the absolute value of D_{st}. The height of the max. related to the interpolated regular distribution of D_{st} at the beginning of the storm was *c.* 40γ ($1\gamma = 10^{-5}$ cm.g.sec) and after 10–15 hr *c.* 15γ. The change with time was exponential. At latitudes of 55–65° on the background of this max. there was observed a low min. value for D_{st}. An explanation is put forward for this complex relation between D_{st} and ϕ. W. HUGHES

550.93

2839. Archeological dating by radiocarbon measurements. J. V. P. LONG. *Atomics* [*London*] **3**, 317–19 (*Dec.*, 1952).

The methods which have been used are reviewed.

F. R. HOLT

ATMOSPHERE . METEOROLOGY 551.5

551.501.8

2840. Comparison of Kew Mk II radiosondes by the method of twin elements. L. MALET. *Publ. Inst. Roy. Météorol. Belgique, No. B*1, 16 *pp.* (1952) *In French.*

In turn soundings were made with a second pressure, temperature or humidity element adjacent to the radiosonde elements but emitting signals simultaneously on a slightly different modulated frequency. Tests for pressure were made to levels of 50 mb, temperature to 200 mb and humidity to 300 mb. The results are tabulated and the errors and standard deviations obtained. No definite relation was established between the pressure error and the temperature correction of the pressure element. The temperature error increases day and night gradually with height to the tropopause. The relative humidity error increases rapidly as pressure falls but decreases beyond 700 mb although the latter may be due to the slower response of the element at low temperatures. In 95% of cases the difference in the indications of two identical adjacent elements $\geq$14 mb, 1·4°c in the troposphere, 1·8°c in the stratosphere and 16% relative humidity up to 700 mb. The main cause of error is the initial shock at release, but this can be reduced by having a rubber cord between the balloon and radiosonde. R. S. READ

551.510.41

2841. Chemical exploration of the stratosphere. F. A. PANETH. *Bull. Soc. Chim. France*, **20**, 1–15 (*Dec.*, 1952) *In French.* Also in *J. Chem. Soc.*, **1952**, 3651–62 (*Sept.*). [Hugo Müller Lecture, March 27, 1952.]

Comprehensive historical review with many illustrations tracing the development of the analysis of the chemical constituents of the atmosphere. Following discussion of ground level measurements, upper air analyses are considered from the first balloon ascents to the use of rockets. It appears that the latter techniques have provided definite evidence for gravitational separation of the rare gases at altitudes >59 km —He and Ne increasing up to 71 km, A decreasing. Previous (conflicting) reports of some evidence for diffusion at lower altitudes are open to question. 38 refs, 3 tables, 6 figs, 14 plates. G. M. BROWN

551.510.5 : 551.593.9

2842. Physics of the high atmosphere. S. F. SINGER. *Nature* [*London*] **171**, 146–8 (*Jan.* 24, 1953).

At the Belfast meeting of the British Association (Sept., 1952) some methods and results of upper atmosphere research were presented by workers in the fields of night air glow, ionospheric radio reflection, high altitude rocket exploration and upper atmosphere theory. Certain discrepancies as well as certain common features between results obtained by these methods lead to conclusions about the dynamic, non-equilibrium state of the atmosphere above 150 km and the desirability of synoptic rocket observations.

AUTHOR

551.510.535

2843. Effects of the variations of recombination coefficient and scale height on the structures of the ionized regions. A. P. MITRA. *Indian J. Phys.*, **26**, 79–102 (*Feb.*, 1952).

Considers in detail the effects of the height gradient of the recombination coefficient and of scale height on the altitude-distribution of ionization for the ionospheric regions, D, E, F_1 and F_2. The characteristics of the gradients are estimated from experimental data. General equations are derived for calculations of height distributions of electrons, taking into account the gradients of recombination coefficient and scale height (to derive the formulae for the D region the results of electron and ion distributions as already calculated by the author (1951) have been used). For the E region the calculated distribution shows that it is not markedly different from the Chapman type of distribution. For the F-region, the gradients as noted above are found to have profound effects, It is found that a simple Chapman layer (which may be identified with the F_1 region) "bifurcates," as it were, into two regions—F_1 and F_2, mainly as a result of the height gradient of the recombination coefficient. This lends support to the contemporary suggestion that the F_2 region is not formed by an ionization process distinct from that for the F_1 region. The effect of the scale height gradient is also estimated. While not affecting markedly the shape of the distribution curve, it makes significant contribution to the value of the ionization density. It is further found that the

bifurcation effect is more pronounced under summer than under winter conditions. However, for a full explanation of the anomalous behaviour of the F_2 region one has to take into account the effect of tidal motions under the influence of the geomagnetic field.

A.

551.510.535

2844. Effects of the solar eclipse of Feb. 25, 1952, on the ionospheric *F*2 region in equatorial Africa. S. Estrabaud. *C.R. Acad. Sci.* [*Paris*] **235,** 1521–3 (*Dec.* 10, 1952) *In French.*

The detailed history of the development of the eclipse as regards its effects on the *F*-layer is traced. The eclipse shows considerable analogies with that observed at Huancayo on Jan. 25, 1944, and supports the hypothesis that the *F*2 region consists of 2 layers, designated *X* and *G*. These are normally amalgamated as a single thick layer, but in eclipse the upper (*G*) component ("old *F*2" layer) is little affected, whereas the *X* component ("new *F*2" layer) suffers a decrease of ionization and appears as a new layer in the *F*1 region. It is suggested that the *G* component may be due to coronal or corpuscular radiation.

G. M. BROWN

551.510.535

2845. Abnormalities in the ionosphere at high latitudes. W. R. Piggott. Letter in *Nature* [*London*] **171,** 124–5 (*Jan.* 17, 1953).

Study of variations of frequency of occurrence of both abnormal *E* and intense *D* ionizations at high latitudes during periods of magnetic disturbance. Within the "storm belt" the disturbances are particularly frequent and intense. The probability of occurrence of both "storm-*E*" and "storm-*D*" ionizations shows a diurnal variation with a maximum. The local time at which this maximum is found varies in a remarkable manner with longitude for storm-*D*, but is practically independent of longitude for storm-*E*. Further, while the probability of occurrence of storm-*D* is almost constant throughout the western hemisphere, the most dense forms of storm-*E* are practically confined to a zone centred near Canada.

G. M. BROWN

551.510.535 : 538.566.3

Radio-wave propagation in the ionosphere. *See Abstr.* 2573–5

551.542

2846. Behaviour of atmospheric pressure systems. T. Schumann. Letter in *Nature* [*London*] **170,** 1077 (*Dec.* 20, 1952).

To study the behaviour of pressure systems 10-degree grid points were selected and the departure at a fixed hour of the daily pressure from the appropriate means were tabulated and expressed as percentages of the respective standard deviations. Dates were then noted over the years 1929–38, when the departure exceeded the standard deviation and was greater than on the preceding and following days. For the 380 days when this occurred the mean pressure at this and other grid points were computed. Mean isobars were thus obtained. The variation with time was obtained by adding one day to each of the listed dates and finding the mean isobars 24 hours later. Curves are shown for three successive days for the 50° parallel. The isobaric pattern moves east at 17·2 knots. Using the parallel of heat diffusion the concept of "diffusion of atmospheric pressure" is introduced. It is considered that laws of pressure diffusion could be derived and applied to prepare prebaratic charts.

R. S. READ

551.575

2847. The microstructure and artificial precipitation of a supercooled fog. H. Dessens. *C.R. Acad. Sci.* [*Paris*] **235,** 1675–8 (*Dec.* 22, 1952) *In French.*

Examination of a supercooled town fog at Les Landais with temperature about −5°c with ultramicroscopic vision showed the presence of rare ice particles in the form of asymmetric crystals. With the fog 200–300 m deep, no cloud above and wind calm 100 g of AgI was dispersed from a generator on the ground. In 12 minutes numerous tiny crystals formed, while precipitation increased quickly in another 20 minutes and the ground became white. In 10 minutes more the fog disappeared from an area of 2 sq km. The precipitation consisted of roughly hexagonal columns, radius 0·08 mm. It is considered that the Bergeron process played an essential role with the AgI as nuclei for the change from supercooled drops to the crystal form. It is estimated that although seeding of clouds is still in the experimental stage, dense fog can be dissipated from a limited area (aerodrome) with a light wind and temperature below −5°c.

R. S. READ

551.577 : 551.594.221

2848. Frontal precipitation and lightning observed by radar. J. S. Marshall. *Canad. J. Phys.*, **31,** 194–203 (*Feb.*, 1953).

A typical pattern (revealed by radar) of precipitation along a cold front includes both showers containing many nearly vertical cells, and continuous rain characterized by uniformity below the freezing level and the "bright band" of melting snow at that level. Observations in vertical section were made by scanning at angles of elevation up to 30°. At wavelength 3 cm, observations of this sort reveal some of the snow above the bright band, and its trailing pattern. At 10·7 cm, little is seen of the snow, but transient echoes with duration of the order of one second are observed, attributable to lightning. These echoes have not been detected when scanning in the vertical at wavelength 3·2 cm, although others have reported something of the sort at 3·2 cm when different observing techniques were used. The transient echoes occur outside, but close to, regions of rain; most frequently about one mile from the top of a shower cell. It is probable, combining 3·2 cm observations of snow on one occasion with 10·7 cm observations of the transients on another occasion, that the transients occur in regions not only near rain, but at the same time in or near a region filled with snow.

A.

551.578.1

2849. The upper bands in the vertical structure of rain echoes. R. Lhermitte. *C.R. Acad. Sci.* [*Paris*] **235,** 1414–16 (*Dec.* 1, 1952) *In French.*

Two radars were used simultaneously on 3·2 cm, one for horizontal and one for vertical structure. Cinematographic registration was used and many

cases examined. Three different types of upper bands were distinguished: (*a*) Upper band slightly inclined and descending at 2–2·5 m/sec to the lower bright band, which is intensified when they meet and so supports Bowen's views; (*b*) slightly inclined bands without change of height and at various levels at the same time; (*c*) markedly inclined bands, which can correspond to the formation of ice particles and the form resulting from the speed of fall of particles and the vertical wind gradient. The rate of fall of particles is obtained as a function of the form of the echo and the wind gradient. The results confirm the view that the bright band at the 0°c isotherm is due to the partial fusion of snow flakes. R. S. READ

551.578.1

2850. Can rain be produced artificially? L. DUFOUR. *Publ. Inst. Roy. Météorol. Belgique, No. B*4, 15 *pp.* (1952) *In French.*

A review is given of the ideas concerning rain formation from earliest times to the Bergeron–Findeisen theory and of the use of solid CO_2 and AgI in seeding clouds, or the possible use of large water drops to produce rain artificially. In considering the results obtained in various countries precipitation is slight and rare from stratiform clouds. For cumuliform clouds results of seeding are said to be conflicting regarding growth or dissipation of cloud, intensity of rainfall, and whether rain might soon have occurred naturally. To change the rainfall of a region the atmospheric circulation must be changed. Seeding a CuNb cloud may prevent growth to the stage where heavy hail will fall. It is concluded that (1) small amounts of CO_2, AgI and other material can transform large clouds from supercooled drops to ice crystals, (2) seeding gives rise to precipitation, mostly slight, and often not reaching the ground, except when heavy, (3) increase of precipitation by seeding is not established because conditions apparently favourable to artificial precipitation are almost the same as those for natural precipitation. A very full bibliography is included. R. S. READ

551.593.5

2851. An experimental study of atmospheric transmission. J. A. CURCIO, L. F. DRUMMETER, C. C. PETTY, H. S. STEWART AND C. P. BUTLER. *J. Opt. Soc. Amer.*, **43**, 97–102 (*Feb.*, 1953).

An experimental investigation was made to determine the general characteristics of the spectral transmission of the atmosphere in the vicinity of Washington, D.C., on the Chesapeake Bay, in the Gulf of Mexico, and in the Central Pacific. Transmission measurements were made at the wavelengths of approximately 15 of the Hg discharge lines in the interval 2500Å to 6000Å. Values of the spectral atmospheric attenuation coefficients (km^{-1}) have been computed. For all observations made, these values increase toward shorter wavelengths and this is most pronounced for wavelengths below 3200Å, where true absorption as well as scattering contributes to the attenuation. A.

551.593.5 : 523.161 : 535.42

The Mie theory of diffraction through dielectric spheres with absorbing cores and its application to problems of atmospheric aerosols. *See Abstr.* 2387

551.593.55

2852. Explanation of the brightness and color of the sky, particularly the twilight sky. E. O. HULBURT. *J. Opt. Soc. Amer.*, **43**, 113–18 (*Feb.*, 1953).

By use of the Rayleigh scattering theory for pure air, primary scattering and known upper air densities from rockets, the brightness of the zenith twilight sky was calculated and values were obtained two to four times greater than those observed at Sacramento Peak, New Mexico [Abstr. 6225 (1952)]. The attenuation of the atmosphere there was observed to be 20% above that of the Rayleigh theory, and the ozone thickness was measured to be about 2·2 mm. When the absorption of the Chappuis band of ozone in the visible spectrum was added to the Rayleigh theory, the calculated sky brightness came into agreement with observation for solar depression angles below the horizon from about 0° to 6°. For the sun below 7° the calculated zenith sky brightness fell rapidly below the observed brightness, showing that primary scattering in the atmosphere above about 60 km does not contribute appreciably to the brightness, as has long been known. Calculation showed that during the day the clear sky is blue according to Rayleigh, and that ozone has little effect on the colour of the daylight sky. But near sunset and throughout twilight ozone affects the sky colour profoundly. For example, in the absence of ozone the zenith sky would be a greyish green-blue at sunset becoming yellowish in twilight, but with ozone the zenith sky is blue at sunset and throughout twilight (as is observed), the blue at sunset being due about $\frac{1}{3}$ to Rayleigh and $\frac{2}{3}$ to ozone, and during twilight wholly to ozone. A.

551.594.21 : 537.533.92

2853. High energy electrons produced in a thunderstorm. J. CLAY, H. F. JONGEN AND A. J. J. AARTS. *Physica*, **18**, 801–8 (*Nov.*, 1952).

A number of cases has been observed in which the presence of high energy electrons of 10^9 eV is directly recorded during thunderstorms. In one instance on May 3, 1952, a 4 to 6% increase above the mean value of the ionization was found in 6 different recording instruments. In one vessel shielded by 110 cm Fe no increase was found. Three cases were noticed in 1951, and since May 3, 1952, three more have been detected. No influence was discovered in vessels with 110 cm iron shielding. The energies lie below 10^{10} eV. An increased ionization was also found during heavy rainfall. A.

551.594.223

2854. Theory of the lightning-balls and its application to the atmospheric phenomenon called "flying saucers." C. BENEDICKS. *Ark. Geofys.*, **2**, *Paper* 1, 1–11 (1952).

An explanation is offered of the phenomenon known as "ball lightning" by assuming the high temperature in the lightning channel to cause thermal dissociation of water, forming overheated oxyhydrogen. The shape of the phenomenon is explained by the action of surface tension. Various other observational characteristics of ball lightning are discussed and these are shown to provide an explanation of reports of "flying saucers." Several cases of unexplained accidents are examined and are shown to support the present proposition. R. H. G.

551.594.6

2855. Long duration echoes from aurora, meteors, and ionospheric back-scatter. D. W. R. McKinley and P. M. Millman. *Canad. J. Phys.*, **31**, 171–82 (*Feb.*, 1953).

In the course of the Ottawa meteor programme some unusual echoes have been detected on 33 Mc/s. Echoes from the aurora are discussed and correlated with visual observations. Two mechanisms of radio reflections from the aurora have been proposed but the data here presented are insufficient to favour one over the other. On Aug. 4, 1948, six extremely long duration meteor echoes were observed which may have been due to abnormal ionospheric conditions. From time to time since August, 1948, a weak semi-permanent echo has been recorded, usually appearing at a range of about 80 km and enduring up to an hour. It is suggested that this echo is due to back-scatter from the same sources in the lower *E*-region that are presumed to be responsible for long-range very high frequency propagation. A.

551.594.7 : 621.396.11

2856. Directly recorded tropospheric refractive index fluctuations and profiles. C. M. Crain. *Trans Inst. Radio Engrs Prof. Group on Antennas and Propagation, No.* 3, 79–83 (*Aug.*, 1952).

Index of refraction fluctuation and profile data obtained with a direct-reading, airborne, microwave refractometer are presented. Included are the following: (*a*) measurements up to 5000 ft off the New Jersey coast; (*b*) measurements up to 11 000 ft over the vicinity of Dayton, Ohio; (*c*) measurements up to 3000 ft off the coast of South-Central California. A.

551.594.7 : 621.396.11

2857. Some methods for evaluating trends in time series of tropospheric radio field strength data. P. L. Rice. *Trans Inst. Radio Engrs Prof. Group on Antennas and Propagation, No.* 3, 144–66 (*Aug.*, 1952).

A short review of several methods for evaluating the "seasonal trend" in a series of hourly median field strengths corresponding to one hour of the day. The presentation is from the viewpoint of descriptive statistics, and no discussion is given of the difficult problem of statistical tests of significance for appraising the components of trend found by these methods. Of three methods investigated, a type of harmonic analysis was found to be the most successful. The other two methods were an adaptation of the smoothing theory of Wiener and Levinson and a method using orthogonal polynomials. A.

551.594.7 : 621.396.11.08

2858. The microwave measurement of variations in atmospheric refractive index. G. Birnbaum, H. E. Bussey and R. R. Larson. *Trans Inst. Radio Engrs Prof. Group on Antennas and Propagation, No.* 3, 74–8 (*Aug.*, 1952).

A microwave refractometer for measuring variations in atmospheric refractive index is described, and certain errors associated with the cavities are discussed. A preliminary account is given of observations obtained with two refractometers and other meteorological equipment installed on a 420-foot tower. A.

551.596.5

2859. Some characteristics of thunder. V. I. Arabadzhi. *Dokl. Akad. Nauk SSSR*, **82**, *No.* 3, 377–8 (1952) *In Russian.*

An apparatus similar to that of Schmidt [*Meteorol. Z.*, 497 (1941)] is described, for recording thunder claps, which is claimed to be much more sensitive than Schmidt's instrument. Recording was made by means of a plywood cubic resonator with a 75 cm reed. In the centre of one of the faces of the cube an opening was made on which was mounted the wooden throat of the resonator, the throat was 3 cm long and had an internal dia. of 1·2 cm. A light aluminium reed which vibrates in response to the thunder was connected to a pen recording on sooted paper. The apparatus was calibrated before and after test by its response to pressure changes. The results obtained did not agree with those of Schmidt, though this might be the result of different experimental conditions. It was found that strong thunder claps as a rule correspond to compressions, and that the greatest energy of the claps occurs at frequencies in the range 0·25–2 c/s, mostly at 0·5 c/s, as against 2 c/s in Schmidt's experiments. W. HUGHES

BIOLOGY 57/59

591.088.5

2860. Effect of soft roentgen rays on the rabbit skin. W. R. Christensen, S. C. Sommers and C. K. Spalding. *Amer. J. Roentgenol.*, **68**, 801–8 (*Nov.*, 1952).

The unfiltered radiation from a beryllium window X-ray tube working at 100 kV has been used to study skin reactions in rabbits over a dose range from 278 to 13 900 roentgens. Gross changes were not observed below 2780 r. Radiation damage at moderate dosage levels was almost entirely limited to the epidermis. Quantitatively the effects were intermediate between those produced by orthodox 100 kV and by grenz radiation. H. MILLER

591.088.5 : 612.014.481.1

2861. Biological evaluation of skin effects of the 23 MeV betatron. L. L. Haas, R. A. Harvey and J. S. Laughlin. *Amer. J. Roentgenol.*, **68**, 644–53 (*Oct.*, 1952).

A comparison of the effects of X-rays generated at 23 MeV and at 200 kV on a variety of skin reactions in rabbits is given. Reference to a small number of similar observations on humans is made. For skin erythema in rabbits the ratio of biological effectiveness of the same physical doses of 23 MeV and 200 kV X-rays is approximately 0·56. For other reactions and other dose rates the relative efficiency is somewhat different. A ratio of efficiency of about

0·60 is observed for tumour reactions in human patients. H. MILLER

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.843.2

2862. Experiments on flicker and some calculations on an electrical analogue of the foveal systems. H. DE LANGE. *Physica*, **18**, 935–50 (*Nov.*, 1952). Also in *T. Ned. Radiogenoot.*, **18**, 1–32 (*Jan.*, 1953) *In Dutch.*

The reaction of the author's right eye to a 2° foveal flicker field has been investigated by tabulating the results of measurements of the critical flicker frequency for various illuminations and various brightness *v.* time functions. It is shown that, when plotting the ripple ratio r = (amplitude of first Fourier component) (average brightness of the stimulus) *v.* the critical frequency f_c, the average brightness being constant, the points observed with various time functions fit into one smooth curve, which at low intensities is monotonous. At high intensities the curve shows a minimum, at which r is inferior to the limiting brightness discrimination ratio, observed for $f \to 0$. By plotting f_c horizontally the curves obtained suggest an explanation of the mechanism present in the light-sensitive organ and the connected nerve centres by analogy with an electric network containing a lowpass filter, a feed-back circuit and a non-linear element transforming the physical stimulus into a number of impulses. A.

612.843.31

2863. Photopic thresholds for red light in an unselected sample of color-deficient individuals. A. CHAPANIS AND R. M. HALSEY. Letter in *J. Opt. Soc. Amer.*, **43**, 62–3 (*Jan.*, 1953).

A semi-circular 1·75° field intermittently illuminated with light of 640 mμ was fixated centrally by 47 observers who determined their absolute thresholds with a neutral wedge. The distribution of the results shows a smooth transition from severely colour-defective to normal observers. A tendency towards bimodality does not seem significant. Some observers making "deuteranopic" chromaticity confusions had "protanopic" thresholds. R. A. WEALE

612.843.35 : 628.972

2864. Brightness discrimination data for the specification of quantity of illumination. H. R. BLACKWELL. *Illum. Engng*, **47**, 602–9 (*Nov.*, 1952).

Gives experimental details and the results of an investigation on two subjects of the speed and accuracy with which a given luminance difference can just be detected in the case of a circular test patch of a given size seen against an extended uniform background. The size range was from 1–64 minutes, the duration, 1–0·001 sec and the luminance 0·001–100 ft.L. J. W. T. WALSH

612.85

2865. The impedance of the human mastoid. J. Y. MORTON. Letter in *J. Acoust. Soc. Amer.*, **25**, 159 (*Jan.*, 1953).

Refers to earlier paper by E. K. Franke [Abstr. 6964 (1952)]. Measurements by the author indicate that over a frequency range 400 to 4000 c/s the average of 13 normal male mastoids has a compliance of $0{\cdot}75 \times 10^{-8}$ cm/dyne, a resistance of 16×10^3 dyne/cm/sec and a mass of 0·73 g. The resonance of individual mastoids varied between 1200 c/s and 4000 c/s according as the flesh covering the mastoid was "fatty" or "leathery." A. B. WOOD

612.85 : 534.62

2866. Early work on the instrumental ear. H. O. TAYLOR. Letter in *J. Acoust. Soc. Amer.*, **25**, 158 (*Jan.*, 1953).

Extracts from a letter from H. O. Taylor to L. L. Beranek giving a brief historical record of progress towards the development of an "instrumental" ear. The note also refers to methods of measuring sound absorption. A. B. WOOD

614.898

2867. Detection of faulty roentgenoscopic technique by direct radiation measurements. S. H. MACHT AND E. R. KUTZ. *Amer. J. Roentgenol.*, **68**, 809–14 (*Nov.*, 1952).

The study was undertaken to measure the average doses received by four radiologists carrying out upper gastrointestinal and barium enema examinations by fluoroscopy and filming. Pocket dosimeters were attached to some 8 points on the head, body, arms and legs; and the summarized doses for a series of examinations showed the importance of the individual's technique as well as the expected factors such as field size, examination time, etc. It is deduced that about 30 such examinations per week should be the maximum carried out if the dose is to be less than the tolerance limit of 0·3 r. L. E. MUSSELL

614.898

2868. The occurrence of lymphocytes with bilobed nuclei in cyclotron personnel. M. INGRAM, M. ADAMS, L. COONAN, J. JESPERSEN, G. NIELSEN, D. PIATT AND G. YETTEWICH. *Science*, **116**, 706–8 (*Dec.* 26, 1952).

Staff on the Rochester 130 in. cyclotron showed approximately 1 in 1000 lymphocytes with bilobed nuclei; they returned to normal when improved protection was erected. The occurrence of such cells is believed to be an exceptionally sensitive index of radiation. F. T. FARMER

615.849

2869. Roentgen therapy dose computing device, especially for rotation therapy with high energy (2 MeV). W. S. MOOS. *Amer. J. Roentgenol.*, **68**, 797–800 (*Nov.*, 1952).

In rotation therapy the doses at a series of points some distance from the axis of rotation are required and each of these can be found by the instrument described. It is a mechanical computing aid incorporating two sliding scales moving over a pattern of concentric circles scribed on a sheet of transparent Perspex which is placed over a cross-section drawing of the patient. The assumptions and conditions on which the method depends are not clearly stated, and there is an apparent lack of correlation between the descriptive matter, the mathematical equations, and the drawings, but it is obvious that the instrument described could perform the function claimed for it.

L. E. MUSSELL

615.849 : 621.395.645.024 : 621.317.79

2870. A direct current amplifier recording system for precise measurement of depth dose. H. E. JOHNS, E. R. EPP AND S. O. FEDORUK. *Amer. J. Roentgenol*, **68**, 788–96 (*Nov.*, 1952).

The principle of the method used is to measure the X-ray dose simultaneously on the surface of a water phantom and at a depth, by displaying each on a pen-recorder and thus allowing precise corrections to be made for time variations in the X-ray intensity. A large-volume monitor chamber mounted in the head of the X-ray set drives the first pen-recorder through a simple d.c. amplifier. A small cylindrical ionization chamber is placed at a chosen depth in the phantom and its output is fed through a battery-driven d.c. amplifier of sufficient gain to drive the second pen-recorder. By comparing the traces at a given time it is stated that depth doses can be measured with an accuracy of 0·5%. Full details are given of the ionization chambers, the amplifier and the mechanical components of the system.

L. E. MUSSELL

PHOTOGRAPHY 77

77.01 : 53.0875

2871. Applications of Fourier integrals to photographic images. III. J. GAULTIER DU MARACHE. *Cahiers de Phys., No.* 40, 29–56 (*Nov.*, 1952) *In French.*

A previous paper [Abstr. 1323 (1953)] is concluded. The photographic images of spectra are compared with the known light intensities, and the transmission of shape, contrast, etc., determined. R. W. FISH

771.4 : 778.6

2872. Application of high speed flash tube to photographing the fundus of the eye in color. M. JACOBS AND K. N. OGLE. *Rev. sci. Instrum.*, **24**, 52–5 (*Jan.*, 1953).

A high speed flash tube is adapted to the Nordensen Retinal Camera, so that the fundus of the human eye can be photographed in colour. The high speed flash eliminates the usually deleterious effect of blinking and eye movements. Special electronic circuits are needed to provide a flickering light from the same flash tube to enable the operator to adjust and focus the camera. Ektachrome film is used and this is over-developed to gain equivalent exposure. For the fundus photographs this apparently results in no loss of colour relationships. A.

771.53

2873. Production of photographic pictures on selenium by crystallization under the action of light. P. SELÉNYI. *Acta phys. Hungar.*, **2**, *No.* 2, 129–39 (1952) *In German.*

If a picture is projected on to a black amorphous Se layer on metal held at 90–100°c the absorbed light accelerates crystallization to a grey form, and a permanent image results. A change of crystal form occurs at 210°c and is used in the preparation of rectifier layers; images similar to those already described can be made at 160°c by the acceleration of this change under light. S. T. HENDERSON

771.535

2874. The photographic behaviour of the silica/silver-ion system. E. E. LOENING AND G. C. FARNELL. *Photogr. J. B.* **92**, 187–94 (*Nov.–Dec.*, 1952).

An examination of the light-sensitive system produced by adsorption of silver ions from aqueous solution on to silica has been carried out, not only for its intrinsic interest but with a view to gaining information on various aspects of latent-image formation in silver-bromide sols. In contrast to the silver bromide system, photo-electrons released by illumination of the silica-silver ion system can only originate from the adsorbed surface layer. The study of the photographic properties of this system, e.g. the dependence of its sensitivity on the number of adsorbed and/or solvated silver ions and hydroxyl ions, its spectral sensitivity, its behaviour at low temperature, latent-image fading, etc., is believed to permit some conclusion on the mechanism of surface latent-image formation in the more complicated silver-bromide system. It is suggested that in both cases the first step to surface latent-image formation consists in the formation of electron traps by exposure of a silver ion complex situated on the surface. A.

778.3 : 535.247.1

Some photographic methods applied to photometry. *See Abstr.* 2308

778.33

2875. Improved α-track autoradiographs of biological specimens. H. LEVI. Letter in *Nature* [*London*] **171**, 123–4 (*Jan.* 17, 1953).

A technique is described using the poured emulsion method to obtain α-track autoradiographs of biological specimens containing opaque substances. The emulsion and the specimen are inverted after photographic processing to permit staining of the specimen and then the inversion process is repeated so that the emulsion can be viewed satisfactorily under the microscope. A. C. COATES

778.33

2876. Modern techniques in high voltage radiography. A. E. BURRILL. *Non-destr. Test.*, **11**, 23–7 (*Oct.*, 1952).

Increased penetration of steel occurs up to 8 MeV, but an analysis of costs shows optimum overall economy to be obtained with 2 MeV X-rays, or with Co^{60}. The effect of scattering is greatest at 500 kV and reaches a constant level when the voltage is raised to about 2 MeV. F. T. FARMER

778.332 : 778.4.

2877. The grid X-ray stereoscope. H. W. KAYSER. *Röntgenblatt.*, **4**, 59–67 (1951).

A description is given of a grid arrangement for stereoscopic X-ray fluoroscopy. Two grids, between which the object is positioned, are located on the tube side of the fluorescent screen; on the observation side is located a grid which, by reduction of the grid opening in favour of the grid mesh, gives the observer

a certain possibility of seeing movement in a stereoscopic image observation field. All three grids are connected by levers and are moved in synchronism by a pendulum action which must be fast enough so that the grids are not perceived by the eyes. Calculations are given for all values, and their dependence upon one another is explained.

PHOTOGRAPHIC ABSTRACTS

778.34

2878. The origins of background tracks in shielded electron-sensitive emulsions. M. C. WALTERS. Letter in *Proc. Phys. Soc.* [*London*] *A*, **65**, 959–60 (*Nov.*, 1952).

The origin of electron tracks in G5 plates shielded from external radiation is shown to be due mainly to K^{40} (40%) and thorium (20%) present in the glass backing. When this source is eliminated by using a Perspex backing, nearly the whole of the remaining tracks are found to be due to C^{14} present in the gelatine. J. H. FREMLIN

778.34

2879. The processing of nuclear emulsions up to 200 microns. K. R. DIXIT. *J. sci. industr. Res.*, 11*B*, 351–5 (*Sept.*, 1952).

A method for processing Ilford nuclear emulsions C2 and G5, 200 μ and 100 μ thick, is described. The process consists in initiating development at a low temperature (< 5°c) and allowing it to go to completion at a higher temperature (< 20°c), checking development in acetic acid stop bath and fixing, without agitation, first in hypo with hardener and then in hypo without hardener. Two photomicrographs are given to illustrate the clarity of the plates; one of them is a rare event showing a negative π meson produced in a fission, producing another fission. A.

778.34

2880. Nuclear emulsion technique. A. BEISER. *Rev. mod. Phys.*, **24**, 273–311 (*Oct.*, 1952).

A detailed review is given of the general properties of nuclear emulsions with special reference to track production, identification and evaluation, to emulsion processing and to a number of specialized techniques including background eradication, impregnation, the detection of neutrons and the recording of γ-ray spectra. A. C. COATES

778.34

2881. On the thickness of tracks due to heavy nuclei in nuclear emulsions. P. CÜER AND J. LONCHAMP. *C.R. Acad. Sci.* [*Paris*] **236**, 70–2 (*Jan.* 5, 1953) *In French.*

The relation due to Freier *et al* [Abstr. 1488 (1949)] between the taper length of a track due to a heavy nucleus and the atomic number of the nucleus is shown to be inexact. A theory is briefly described, based on the number and range of δ-rays produced near the end of the tracks, which supports the linear relation between the atomic number and taper length found experimentally by Hoang–Chang–Fong and Morellet [Abstr. 2279 (1951)]. A. C. COATES

778.34

2882. Range-energy relations for alpha-particles and deuterons in the Kodak NTB emulsion. O. GAILAR, L. SEIDLITZ, E. BLEULER AND D. J. TENDAM. *Rev. sci. Instrum.*, **24**, 126–8 (*Feb.*, 1953).

Range-energy relations for α-particles (3–18 MeV) and deuterons (2–9 MeV) in the Kodak NTB emulsion have been determined. Natural α-emitters and particles accelerated in the Purdue University cyclotron were used. Cameras for use with the cyclotron and with Po and Th sources are described. In the energy interval investigated the ranges in the N.T.B. emulsion are practically identical with those found in the Ilford B1 and C2 emulsions. They agree also with the ranges previously reported in dry Kodak NTA emulsions, but are as much as 10% shorter than those reported for the latter emulsion when exposed under "ordinary" humidity conditions. A.

778.34

2883. Search for "*T*"-tracks in photographic plates. P. H. BARRETT, G. COCCONI AND Y. EISENBERG. Letter in *Phys. Rev.*, **89**, 656 (*Feb.* 1, 1953).

In an area of 112 cm² of 400μ G.5. emulsion, 2191 nuclear disintegration "stars" were found with 4246 tracks ending in the emulsion. The number of "*T*"-tracks found is approximately the number expected on the basis of chance passing of a "light" track near the end of a "black" track, whereas Blau and Salant [Abstr. 1102 (1953)] find that "*T*"-tracks are more frequent than can be explained by chance coincidences. A. C. COATES

778.34 : 77.023.4

2884. Discrimination between the tracks due to charged particles and fog due to gamma radiation, in nuclear emulsions. M. GAILLOUD AND C. HAENNY. *Sci. Industr. photogr.*, **23**, 221–4 (*June*, 1952) *In French.*

The technique of partial latent image destruction to obtain discrimination between γ-ray fog and tracks due to low-energy α-particles cannot be used with a normal solvent developer since the latent image formed by the α-particles is more in the nature of a surface image compared with that produced by γ-radiation. Satisfactory discrimination can be obtained in Ilford C2 plates, exposed to 30 roentgens of gamma radiation, by under-development at low pH. See also abstract following. A. C. COATES

778.34 : 77.023.4

2885. Selective development of nuclear emulsions. Discrimination between tracks and gamma-ray fog. M. GAILLOUD AND C. HAENNY. *Mem. Soc. Vaudoise Sci. Nat.*, **10**, *No.* 5, 271–94 (1952) *In French.*

An exposure of 2 roentgens of gamma radiation from radium is sufficient to completely fog an Ilford C2 emulsion using a normal solvent developer (1D19 diluted 1 : 3). By decreasing the pH of this developer, the fog produced by exposing the plates to 30–40 roentgens of γ-radiation is low enough to allow satisfactory recognition of tracks due to low-energy α-particles. The limit of γ-ray exposure can be increased up to 200 roentgens if the plates are developed in a surface developer (glycin-carbonate), used at a low pH. See also preceding abstract. A. C. COATES

778.37 : 621.383.8

2886. Image converter tubes and their application to high speed photography. J. S. COURTNEY-PRATT. *Photogr. J.B*, **92**, 137–48 (*Sept.–Oct.*, 1952).

Image converter tubes have been used for photographing detail of phenomena occurring in 10^{-8}–10^{-9} sec. An optical image of the phenomenon is focused on to the photosensitive surface. The electron stream is deflected as a time base. Photographs of the fluorescent screen are then similar to the records ordinarily obtained with drum or mirror cameras. Time-base writing speeds up to 300 000 m/sec have been used—i.e. 100 times faster than the best mirror cameras. As there are no mechanically moving parts vibration is eliminated. The resolution is better than 1250 photographic lines across the fluorescent screen 10 cm in dia. The deflection distortion has been reduced to less than 1% of the deflection amplitude. Photographs have been taken of the detonation of explosives, of electrical discharges, and of the delay a pulse of light experiences in travelling 3 m. By applying the anode (or grid) potential as a pulse of short duration the tube can be made to act as a shutter. Ordinary two-dimensional photographs can be obtained with an exposure time of 5×10^{-8} sec. Combinations of deflection and pulse operation are possible. At normal magnification the overall effective aperture of the tube and lenses is *f*/4. The electrical magnification is continuously controllable over a range of 5 : 1. The image intensity as a function of the electrical and optical magnifications and of the type of lens system is discussed in some detail. At small electrical magnifications, the tube can act as an image intensifier. The versatility and resolution of the methods make them suitable for the study of combustion and detonation, vibration and fracture, electrical discharges and many branches of ballistics. A.

778.37 : 621.383.8

2887. Image converter techniques applied to high speed photography. R. A. CHIPPENDALE. *Photogr. J.B*, **92**, 149–57 (*Sept.–Oct.*, 1952).

In an image converter, a latent image exists for a time as a beam of electrons. A convertor can be used in many different applications by the influence of suitable voltage pulses deflecting fields on the electron beam. A method of using the ME.1201 image converter as a high-speed shutter is described in detail, and the performance and limitations of the equipment are considered. High-speed scanning and stroboscopic methods are also discussed. Satisfactory single shot exposures of 3×10^{-8} sec and scanned traced writing speeds of up to 100 000 m/sec at the fluorescent screen have been achieved. A.

778.534.83 : 771.447.9 : 621.383

2888. A synchronized flash-discharge system for high-speed 35 mm. cinematography. W. D. CHESTERMAN AND G. T. PECK. *Photogr. J.B.*, **92**, 133–6 (*Sept.–Oct.*, 1952).

An account is given of the development of a power stroboscope which will allow high-speed flash photography at picture rates up to 4000/sec. The light source of the stroboscope is a xenon-filled flash tube constructed from quartz and so designed that the total duration of the flash is of the order of 5 μsec; the energy in each flash is 4 Js regardless of the operational frequency. A 35 mm high-speed cinematograph camera is described which takes full-size pictures at repetition rates from 100–2000 per sec, the film capacity is 200 ft, and films taken can be projected in the normal way. Optical compensation for the film movement during exposure is provided by a rotating cubical glass prism interposed between objective and film; for half-height pictures an octagonal glass prism is used and the maximum repetition rate is then 4000 per sec. The instrument can be used with either continuous light on the subject, or synchronized with the flashing light source of the high speed power stroboscope. A.

778.554.2

2889. Colour kinematography and the human eye. R. W. G. HUNT. *Brit. Kinematogr.*, **19**, 173–80 (1951).

A comparison is made between the colour sensitivity of the eye and the ability of various colour-films to cover adequately a similar range in proportional hues and intensities. It is demonstrated that it is impossible to stimulate the various regions of the eye in a manner identical to that found in nature when presenting for inspection various combinations of blue, green and red light *via* any colour-reproducing optical system such as a kinema projector. The unimportance of correct colour reproduction is discussed in relationship to mental comparisons of variations in brilliance, in saturation and in hue. The recent introduction of colour-couplers in the reproduction of mono-pack colour film either as printed transparencies or on paper base is shown to effectively reduce the loss of colour balance previously encountered when multiple copies from original mono-pack colour films are made. PHOTOGRAPHIC ABSTRACTS